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A BIBLIOGRAPHY OF CHLOROPICRIN, 1848–1932[1]

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INTRODUCTION

Chloropicrin is trichloronitromethane, CCl_3NO_2. It is also called nitrochloroform, and during the World War it was known as vomiting gas, acquinite, G-25, S-1, and PS. It is a colorless liquid and has the following properties (*326*)[2]: Molecular weight, 164.38; melting point, −64° C.; boiling point, 112.4°; specific gravity at 0°/4° C., 1.692; refractive index $n_D^{20^\circ}$, 1.4595.

According to Baxter, Bezzenberger, and Wilson (*45*) the values for vapor pressure of chloropicrin are: At 0° C., 5.7 millimeters Hg; at 20°, 18.3 millimeters Hg; at 25°, 23.8 millimeters Hg.

Thompson and Black (*473*) found the solubility of chloropicrin in water to be 2.272 g per liter at 0° C., and 1.141 g per liter at 75°.

Although the molecular weight of chloropicrin indicates a theoretical specific gravity of its vapor of 5.7 (air=1), Roark and Nelson (*413*) have shown that the tendency of chloropicrin vapor to fall under practical fumigating conditions is more accurately represented by the figure 1.1458, which is the specific gravity of air saturated with chloropicrin vapor at 25° C. and 760 millimeters of mercury pressure, compared to pure air under the same conditions. Roark and Nelson (*412*) have calculated from vapor-pressure data the quantity of chloropicrin vapor capable of existing in a space of 1,000 cubic feet at temperatures ranging from 0° C. (32° F.) to 50° C. (122° F.). The value at 0° is 3.4 pounds, at 20°, 10.3 pounds, and at 25°, 13.1 pounds. The minimum lethal concentrations of chloropicrin vapor to insects and rats are greatly below these values.

Chloropicrin was first prepared in 1848 by Stenhouse (*455*), who added an aqueous solution of picric acid to an excess of bleaching powder. It remained largely a laboratory curiosity until the World War, when it was used on a large scale in shells, both as a lachrymatory and a lethal gas. It was used chiefly because of its peculiar property of causing vomiting when inhaled, thus inducing the soldier to remove his mask and expose himself to the action of gases which penetrated the mask less readily. Chloropicrin was generally mixed with other gases, especially phosgene and diphosgene. A mixture of 80 percent chloropicrin and 20 percent stannic chloride (later a mixture of silicon and titanium chlorides) was also used by the Allies. On January 1, 1919, Edgewood Arsenal, Md., had an estimated capacity of 3,000,000 pounds of chloropicrin per month.

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[1] This is a revision of Chemistry Bibliography no. 1, Chloropicrin, by R. C. Roark, issued in 1926; and Supplement to Chloropicrin Bibliography, by R. C. Roark, issued in May 1927; and Supplement to Chloropicrin Bibliography, by W. A. Gersdorff, issued in October 1930. These were published in mimeographed form and contained 287, 29, and 80 references, respectively, to the literature. Grateful acknowledgment is made to those who contributed references to this bibliography, especially F. L. Campbell, of the Bureau of Entomology, and A. L. Strand, of the Montana Agricultural Experiment Station.

[2] Italic numbers in parentheses are the citation numbers.

As early as 1907 chloropicrin emulsified in water with soap was proposed as an insecticide by the Chemische Fabrikwerke G.m.b.H. of Austria (*229*). Tests with chloropicrin as an insecticidal fumigant were first made about 1917 by Moore in the United States (*311*) and by Piutti and Bernardini (*369*) in Italy, and in 1918 by Bertrand (*50*) in France.

The advantages of chloropicrin as a fumigant are: High toxicity to many species of insects and rats; fungicidal and bactericidal properties; complete freedom from fire and explosion hazards; low solubility in water; ability to penetrate bulk commodities; nonreactivity with metals, fabrics, and colors under fumigating conditions; and a pronounced odor and lachrymatory effect which usually effectively warn of its presence.

Its disadvantages are: Slowness in action, as compared to hydrogen cyanide; tendency to act detrimentally on living plants and seeds; difficulty in removing its odor from fumigated commodities and spaces; and nauseating effect upon the operator.

The combination of chloropicrin with carbon dioxide, found by Cotton and Young (*109*) to be more toxic than chloropicrin alone to many insects, should prove useful in fumigating stored materials and even living plants and trees, and is worthy of further trial.

The references to work with chloropicrin given here are offered in the hope of stimulating additional work with a compound which is not only a potent insecticide but in addition possesses distinct fungicidal and bactericidal properties.

BIBLIOGRAPHY

ANONYMOUS. (1)

DIE CHEMIE IM KRIEGE. Ztschr. Angew. Chem. 31: 163–164. 1918.

Chloropicrin is listed as one of the war gases used by the Germans.

——— (2)

DAS GAS ALS KAMPFMITTEL. Chem. Ztg. 43: 366. 1919.

Chloropicrin was used by the English with about 20 percent ethyliodo acetate or tin tetrachloride, and by the Russians mixed with an equal part of sulphuryl chloride. The Russians in the fall of 1916 used sodium hydrogen sulphite and hexamethylenetetramine in masks as a protection against chloropicrin.

——— (3)

EDGEWOOD FACTS. Chem. Warfare 2 (3): 9–10. 1919.

At Edgewood Arsenal, Md., 2,776 tons of chloropicrin were produced, 1903 tons of which were shipped overseas. Chloropicrin-stannic chloride mixture was used to fill shells.

ANONYMOUS—Continued. (4)

UNITED STATES CHEMICAL WARFARE SERVICE. Sci. Amer. 120: 318–319, 326–327, 372–373. 1919.

Chloropicrin was produced at Edgewood Arsenal by the action of bleaching powder upon calcium picrate. It was used as a filler for projectiles of all kinds, some shells being filled entirely with chloropicrin, and others with a mixture of chloropicrin and phosgene or stannic chloride (p. 372). A photograph of a chloropicrin plant is shown on p. 319.

——— (5)

GAS MASK ABSORBENTS. Chem. Warfare 4 (4): 3–17. 1920.

The absorption service time of the charcoal in gas masks using 7,000 parts per million of chloropicrin is 65 minutes at 0° C., and 47 minutes at 40°. Stannic chloride, if mixed in equivalent quantities with chloropicrin, will decrease the service time against chloropicrin by about 50 percent; chlorine and also water similarly hasten the breakdown of charcoal toward chloropicrin. One fifth of an equivalent quantity of cyanogen chloride mixed with an air-chloropicrin mixture has but little effect on the breakdown of charcoal against chloropicrin. The service time of different charcoals for chloropicrin, phosgene, hydrocyanic acid, etc., is shown in tables.

——— (6)

LA LUTTE CONTRE LES INSECTES. Prog. Agr. et Vitic. (Ed. l'Est-Centre) 73: 614. 1920.

An account of the meeting of June 4, 1920, of the Société de Pathologie Végetale at which Vayssiere reported on the control of Moroccan crickets (*Dociostaurus maroccanus*). One of the means used was emulsions of chloropicrin.

——— (7)

BRICIOLE. LA CLOROPICRINA NELLA DISINFEZIONE DEI CEREALI. Coltivatore 67 (27): 277–278. 1921.

An abstract of the work of Piutti and Mango with chloropicrin for the fumigation of cereals.

——— (8)

DESTRUCCION DE LOS INSECTOS DE LAS SEMILLAS. Inform. Agr. [Madrid] 11 (240): 160. 1921.

An abstract is given of the work of Miege (*305*) with chloropicrin.

——— (9)

KILLING WEEVILS WITH CHLOROPICRIN. Amer. Miller 49: 1140. 1921.

The scarcity of insect pests around Rheims is attributed to the use of poisonous gases in that region during the World War. French scientists have found that 20 to 25 g of chloropicrin to each bag (220 pounds) of grain in a closed room will kill all weevils in 20 hours at a temperature of 50° to 54° F.

——— (10)

UN NUEVO Y MUY EFICAZ INSECTICIDA. LA CLOROPICRINA. Bol. Agr. Indus. y Com. Guatemala 1 (1): 25–26. 1921.

A review of the work of Moore (*312*) with chloropicrin as an insecticidal fumigant.

——— (11)

PHYSICAL AND CHEMICAL PROPERTIES OF BROMBENZYLCYANIDE AND OTHER LACHRYMATORS. Chem. Warfare 7 (2): 10–16. 1921.

Chloroacetophenone may be mixed with chloropicrin and TNT without reaction. It is more stable than brombenzylcyanide, but it is rather more active than chloropicrin (p. 16).

——— (12)

TACTICAL CLASSIFICATION OF GASES. Chem. Warfare 7 (7): 2–4. 1921.

Chloropicrin is given as the typical gas of the class used for the purpose of producing casualties, belonging to the group of nonpersistent deadly gases which are effective for several hours after release on the target.

ANONYMOUS—Continued. (13)

INSTRUCTIONS FOR HANDLING CHEMICAL WARFARE MATERIAL IN A RAILROAD WRECK. Chem. Warfare 8 (2): 6–9. 1922.

Chloropicrin is irritating to the eyes before dangerous concentrations are reached. It is very persistent and is absorbed and given off slowly by nearly everything with which it comes in contact. All combustible material which has been subjected to the action of chloropicrin should be destroyed by burning. Inclosed places, which cannot be burned, must be thoroughly ventilated until the odor is gone. Chloropicrin is transported in shells or grenades, and in bulk in drums and 1-ton containers. The gas mask is efficient against it (p. 7).

——— (14)

REPORT ON IMPROVISED PROTECTION AGAINST TOXIC GASES. Chem. Warfare 8 (3): 8–9. 1922.

Chloropicrin is persistent, and its destruction by ordinary means is difficult. Gassed patients should have plenty of air. For the eyes, a 2 percent solution of sodium bicarbonate or a saturated solution of boric acid is helpful.

——— (15)

THE CHEMICAL WARFARE SERVICE—ITS ACTIVITIES AND ACHIEVEMENTS. Mech. Engin. [New York] 45: 645. 1923.

An ash-free and chlorine-free charcoal was developed. When placed in a cartridge it was used to adsorb gases from the atmosphere. Entirely satisfactory results have been obtained when analyzing air containing chloropicrin or mustard gas. The portable machine for drawing and measuring large samples of air is pictured.

——— (16)

THE TACTICAL EMPLOYMENT OF CHEMICAL AGENTS BY ARTILLERY. Chem. Warfare 9 (1): 2–10. 1923.

Chloropicrin is known as PS and is classified as a low persistent gas similar in tactical action to NC, which is a mixture of 80 percent chloropicrin and 20 percent stannic chloride.

——— (17)

WAR GAS PUT TO PRACTICAL USE. Minn. Agr. Expt. Sta. Ann. Rpt. (1923–24) 32, pt. 4, 29 p., illus. 1925.

For the fumigation of the buffalo beetle and the true clothes moth in rooms, a mixture of equal volumes of chloropicrin and carbon tetrachloride has been successfully used. A series of atomizers connected together is placed in the room and connected with a pressure tank outside the house. In this way the operator can fumigate without the use of a gas mask. Illustrations of the atomizing equipment and of a gas mask for use in hand spraying with chloropicrin are given. Chloropicrin is equally valuable against other household pests and has been used with marked success in the fumigation of mills and elevators (p. 27–29).

——— (18)

CHEMICAL WARFARE AGENTS AND FIRST-AID TREATMENT. CHLOROPICRIN. Chem. Warfare 12 (4): 17–18. 1926.

The physical and chemical properties and early history of chloropicrin are briefly described.

——— (19)

SUGGESTIONS FOR THE ADMINISTRATION OF FIRST AID TO PERSONS SUFFERING FROM EXPOSURE TO CHEMICALS OR GASES. Chem. Warfare 12 (6): 10–16. 1926.

Chloropicrin is described as an oily liquid, a lung irritant with an odor like that of fly paper. It produces cough, burning of the skin, and lachrymation, followed by nausea, retching, and vomiting. The patient should be removed to a pure atmosphere and kept quiet in a recumbent position. Apply warmth, give light stimulants. In case of splashes of liquid on the skin, wash off with alcoholic disodium sulphite at once to prevent ulcerations (p. 13).

ANONYMOUS—Continued. (20)
THE USE OF INSECTICIDES IN GRANARIES. Oil Colour Trades Jour. 70: 1946. 1926.

For the protection of grain in storage in Algeria, chloropicrin has given excellent results. It has to be sold under a permit on account of its toxic nature. The storeroom should be hermetically sealed. Two thousand seven hundred metric tons of wheat was treated with 100 kg of chloropicrin. After 2 weeks' exposure all weevils, rats, and mice were killed. In silos, 5 liters of chloropicrin with 3 weeks' exposure suffices for 90 metric tons of grain. It is necessary that the workers opening the silo wear gas masks and that the grain be thoroughly aerated. Flour and bread prepared from the treated grain had no bad flavor. In germinating tests from 93 to 98 percent of the seeds sprouted.

——— (21)
LA PIQURE DU BOIS DE CHENE MIS EN OEUVRE, CAUSES, MOYENS DE PROTECTION. Rev. Zool. Agr. 30: 174–180, 191–195. 1931. [Abstract in Rev. Appl. Ent. (A) 20: 241. 1932.]

The chief species of beetles that bore into lumber, particularly oak, in France are *Lyctus linearis* Goeze, *L. brunneus* Steph, *Anobium punctatum* DeG. (*striatum*, Ol.), *Xestobium rufovillosum* DeG. (*A. tessellatum* Vill.) and *A. castaneum* var. *hirtum*, Ill. Beetles in lumber are destroyed preferably by fumigation with sulphur or chloropicrin in hermetically sealed chambers. Where infestation exists in woodwork in buildings, the rooms should be fumigated with one of these substances.

A., E. (22)
YPÉRITE ET GAZ TOXIQUES. Monit. Sci. (5) 9: 149–158. 1919.

Chloropicrin is listed as one of 31 war gases and is classified as a moderately persistent gas. It was used in shells, both alone and mixed with diphosgene [$(COCl_2)_2$], in the ratio of 35 percent chloropicrin and 65 percent diphosgene.

ALEKSEEVSKII, E. V. (23)
ADSORPTION OF VAPORS BY ANIMAL AND VEGETABLE FIBERS. Zhur. Prikladnoi Khim. 1: 184–189. 1928. [Abstract in Chem. Abs. 23: 4346. 1929.]

Chloropicrin is best adsorbed by dyed new wool and dyed used silk. Linen is the poorest adsorbent. Chloropicrin does not affect the fiber strength.

——— and ALEKSEEV, N. S. (24)
ACTION OF BENZYL BROMIDE AND CHLOROPICRIN VAPORS ON SMOOTH METALLIC SURFACES. Zhur. Prikladnoi Khim. 1: 194–200. 1928. [Abstract in Chem. Abs. 23: 4398–4399. 1929.]

At room temperature benzyl bromide is less destructive than chloropicrin. Benzyl bromide is more active in a dry atmosphere, whereas chloropicrin is more active in a humid atmosphere. Chloropicrin in a dry atmosphere and benzyl bromide in either a dry or a humid atmosphere do not destroy metals completely as metals gradually acquire passivity. In the presence of moisture chloropicrin completely destroys metals. Volatile compounds are sometimes formed by the action of chloropicrin on zinc and tin in a dry atmosphere. Curves of the reaction rates show that the process is very complicated.

ALLEN, E. W., BEAL, W. H., and FLINT, E. R. (25)
WORK AND EXPENDITURES OF THE AGRICULTURAL EXPERIMENT STATIONS 1922. U.S. Dept. Agr. Off. Expt. Stas. Rpt. 1924.

The Minnesota station showed that for the control of grain insects a mixture of 90 percent carbon tetrachloride and 10 percent chloropicrin was more toxic than either one alone (p. 55).

ALTSON, A. M. (26)
BEETLES DAMAGING SEASONED TIMBER: IV. METHODS OF TREATMENT. Timber Trades Jour. 91: 1171. 1922.

For the fumigation of timber in airtight rooms, stores, or fumigation tents, chloropicrin can be used with success at a temperature of 24° C. and above. Used at the rate of 1 pint (1¾ pounds) per 1,000 cubic feet, it is effective in 24 hours, but the duration of the treatment must be extended for timber more than three fourths of an inch thick. The liquid should be poured into wide-mouth crocks; or it can be poured upon a concrete floor.

ARGO, W. L., JAMES, E. M., and DONNELLY, J. L. (27)
TETRACHLORDINITROETHANE. Jour. Phys. Chem. 23: 578–585. 1919.

Tetrachlordinitroethane is a white crystalline solid having a melting point of 142 to 143° C. It is insoluble in water and soluble in alcohol, ether, and ligroin. In ether and ligroin it decomposes at 60°, with evolution of brown fumes. It is also very soluble in liquid N_2O_4. [30 cc of dry N_2O_4 distilled from P_2O_5 will dissolve 15.7 g of $C_2Cl_4(NO_2)_2$ at 0°.] The solubility in superpalite and chloropicrin was not determined quantitatively, but seemed to be of the same order. Tetrachlordinitroethane is toxic to mice at one sixth the concentration for chloropicrin, and produces lachrymation in man at one eighth the concentration that chloropicrin does.

ARKHANGEL'SKII, N. N. (28)
THE DISINFECTANT PROPERTIES OF GASEOUS POISONOUS SUBSTANCES. Bul. N. Caucas. Pl. Prot. Sta. 5: 3–44. 1930. [In Russian. Abstract in Rev. Appl. Ent. (A) 19: 4–5. 1931.]

An account is given of laboratory experiments, carried out in 1926 in Rostov-on-Don, to compare carbon bisulphide (CS_2) and chloropicrin (CCl_2NO_3) as fumigants for pests of stored products, particularly *Calendra granaria* L. A parallel experiment showed that sudden changes in temperature are fatal to this weevil. Exposure in the grain for 24 hours to a temperature of —3° C. (26.6° F.) after 10° (50° F.), and then again to 13° (55.4° F.) killed 66 percent in 10 days.

The susceptibility of the various pests to the two fumigants, which varied widely, is shown in graphs. *Tribolium confusum* Duv. and *Laemophloeus testaceus* F. were the most resistant, the more susceptible species in order of resistance being *Tyroglyphus* sp., the eggs of *Ephestia kühniella* Zell., and *Plodia interpunctella* Hb., *Calendra* [*Sitophilus*] *oryzae* L., *Sitodrepa panicea* L., *C. granaria*, *Tenebroides mauritanicus* L., and *Oryzaephilus* [*Silvanus*] *surinamensis* L.

The minimum fatal dosages for the various species at temperatures of 21° to 22° C. (69.8 to 71.6° F.) and an exposure of 8 hours in empty granaries are shown in diagrams. All the species were killed with 95 ounces carbon bisulphide or 8.95 ounces chloropicrin to 1,000 cubic feet, accelerated evaporation being necessary in the case of the latter.

Low temperatures necessitate larger quantities of the fumigant, but the relation of these two factors is irregular, and when the amount of the fumigant is decreased and the exposure prolonged, the mortality of the insects does not increase in regular proportion to the length of exposure.

In the case of chloropicrin an economy of 1 ounce to 1,000 cubic feet was obtained by placing the fumigant in the deeply concave lid of a tank of boiling water, the heat causing it to evaporate in 10 to 15 minutes as compared with 9 hours when it was kept cold. The cost of fumigating with carbon bisulphide and chloropicrin is compared. With an exposure of 8 hours and temperatures below 21° C. (69.8° F.), chloropicrin is considerably cheaper; at higher temperatures there is a marked decrease in the amount of carbon bisulphide required and the cost of the two substances becomes almost equal. Accelerated evaporation decreases the dosage, and consequently the cost, of both fumigants.

Observations on the absorption of the fumigants by the grain indicated that in full granaries the dosages of carbon bisulphide should be increased by 15 to 25 percent in order to attain complete control in 8 hours at 25° to 27° C. (77 to 81.6° F.), whereas that of chloropicrin should be increased by 280 percent. As the grain continues to give off the absorbed gas for some time, repeated ventilation of the granary is required, especially in view of the lachrymatory properties of chloropicrin.

In experiments on the effect of different atmospheric pressures on the insects during fumigation, it was found that a low pressure was more satisfactory, an increase from 1½ to 3 atmospheres decreasing the mortality of *Calendra granaria* by 24 percent and of *Tribolium confusum* by 56 percent.

The rapidity of the penetration of the fumigants is discussed as well as its dependence on temperature, dosage, atmospheric pressure, mode of evaporation, and kind of product fumigated. The author concludes that the toxicity of chloropicrin averages only 8 to 12 times higher than that of carbon bisulphide, and that it is more expensive for use in full granaries.

ARNAUD (29)
EXPERIENCES DES DESTRUCTION DES VERS BLANCS. Vie Agr. et Rurale 25: 101–102. 1924.

A solution of chloropicrin was prepared by adding 1 liter of a well-emulsified soapy solution of chloropicrin and 1 liter of bicarbonate of soda solution to 200 liters of water. Experiments to determine its action upon the eggs of the "hanneton" (*Melolontha vulgaris*) were inconclusive. Weed seeds were destroyed by chloropicrin; legumes and vine grafts planted 4 days after spraying did not suffer.

ASTON, E., and RAMSAY, W. (30)
THE MOLECULAR FORMULAE OF SOME LIQUIDS AS DETERMINED BY THEIR MOLECULAR SURFACE ENERGY. Chem. News 69: 57–58. 1894.

From the molecular surface energy and its variation with temperature, chloropicrin is found to have a normal molecular weight.

AUER, J. (31)
EXPERIMENTAL GENERALIZED ANALGESIA AFTER EXPOSURE TO SOME WAR GASES. Jour. Expt. Med. 35: 97–114, 1922.

Cats gassed with dimethylsulphate or chloropicrin in such concentrations that death generally results within 4 days usually exhibit a marked generalized analgesia, both superficial and deep. Gassed cats react with no obvious sign of pain to operative interferences, including laparotomy and gentle friction of the parietal peritoneum. The analgesia develops within a few hours after gassing and reaches its maximum in about 24 hours. With chloropicrin practically normal sensitiveness has been observed 7 days after gassing. This analgesia is considered to be caused and maintained largely by a general, low-grade tissue asphyxia, which is chiefly of pulmonic origin. In most instances death occurred within 48 hours after gassing with chloropicrin, 1 to 10,000, for one half to 1 hour.

AULD, S. J. M. (32)
GAS AND FLAME IN MODERN WARFARE. 201 pp. New York. 1918.

The German green cross mixture contained diphosgene and chloropicrin, or vomiting gas (p. 156).

AUSTRAN, A. (33)
AN IMPROVED METHOD OF DISINFECTING AND DESTROYING HARMFUL ANIMALS AND VERMIN. British Patent 292,547, applied for March 23, 1928; in France, June 22, 1927. Complete, not accepted.

Fumigants, for example, hydrocyanic acid or chloropicrin, are absorbed by a spongy pad placed in a gas-tight tube. For use the tube is taken apart and the gas allowed to evaporate.

AUWERS, K. v., and HARRES, L. (34)
ZUR SPEKTROCHEMIE ALIPHATISCHER NITROVERBINDUNGEN. Ber. Deut. Chem. Gesell. 62: 2287–2297. 1929.

Chloropicrin is shown to have a normal nitro structure.

AVERIN, V., and NOVINENKO, A. (35)
[A CONTRIBUTION TO THE PROBLEM OF THE CONTROL OF PESTS OF ARCHIVES.] Kharkiv. kr. sil.—Gosp. Disvidna Stantz. Ent. Dept. No. 9, 1928. [In Ukrainian. Abstract in Rev. Appl. Ent. (A) 18: 89. 1930.]

Fumigation with 3 ounces of chloropicrin to 50 cubic feet did not damage the paper, colored illustrations, photographs, etc., of books and documents and killed all exposed larvae of *Sitodrepa panicea* L. in 1 hour, and at half this concentration in 2 hours. As some of the fumigant is absorbed by the paper, a longer exposure was necessary to kill those in the infested material; namely, 48 hours, 1 ounce being used to 50 cubic feet, or 24 hours, 2 ounces being used.

BACK, E. A., and COTTON, R. T. (36)
STORED-GRAIN PESTS. U.S. Dept. Agr. Farmers' Bul. 1260, 46 p., illus. 1931.

Chloropicrin is mentioned as a nonflammable tear gas, highly toxic as a fumigant for grain insects. The development of better methods of application may greatly increase its use for fumigating grain (p. 46).

BACKER, H. J. (37)
L'ACIDE METHANETRISULFONIQUE. Rec. Trav. Chim. Pays-Bas 49: 1107–1117. 1930.

From chloropicrin and potassium sulphite, the potassium salt of methane trisulphonic acid, $CH(SO_3K)_3$ may be obtained (p. 1108).

BANCROFT, W. D. (38)
THE CHEMISTRY OF WAR GASES. MEDICAL ASPECTS OF GAS WARFARE. *In* The Medical Department of the United States Army in the World War. v. 14, p. 295–306. Washington, D.C. 1926.

Chloropicrin is included in a list of gases used by the Germans. Its physical and chemical properties are described. It is moderately toxic, 0.8 mg per liter (110 p.p.m.), and somewhat lachrymatory, 0.016 mg per liter. Chloropicrin gives a pink color with a suitably prepared solution of alphanaphthol and a blue color with a different solution of betanaphthol. A concentration of one in a million can be detected by passing the air through a sodium ethylate solution and testing for sodium nitrate (p. 297–298).

BARCROFT, J., HUNT, G. H., and DUFTON, D. (39)
THE TREATMENT OF CHRONIC CASES OF GAS POISONING BY CONTINUOUS OXYGEN ADMINISTRATION IN CHAMBERS. Quart. Jour. Med. 13: 179–200. 1920.

Patients poisoned with chloropicrin and other gases were placed in chambers in which the percentage of oxygen was maintained between 40 and 50. The usual term of residence was 5 days, 16 or 17 hours of each day being spent in the chambers; the night was always spent in them. This treatment reduces the red cell count to about 5,000,000, benefits the pulse rate, relieves from attacks of nocturnal dyspnoea, and increases the patient's capacity for exercise without becoming breathless.

BARKER, M. E. (40)
THE PROTECTION OF ENCLOSED SPACES FROM NOXIOUS GAS. Chem. Warfare 13 (1): 2–5. 1927.

Protective measures, such as gas masks and gas-proof shelters, against various war gases, including chloropicrin, are outlined.

BASKERVILLE, C. (41)
REPORT OF THE COMMITTEE ON OCCUPATIONAL DISEASES IN THE CHEMICAL TRADES. Jour. Indus. and Engin. Chem. 13: 568–569. 1921.

Reference is made to the report of Shufflebotham (*438*) who stated that " with the exception of phosgene gas, workers engaged in the production of other poison gases have enjoyed a high degree of immunity from influenza infection." The gases manufactured where the investigation was made were hydrogen sulphide, chloropicrin, chlorine, mustard, and phosgene.

BASSETT, H. (42)
ON THE TETRABASIC OR ORTHOCARBONATE OF ETHYL. Jour. Chem. Soc. [London] 17: 198–202. 1864.

By the action of metallic sodium on a solution of chloropicrin in absolute alcohol the orthocarbonate of ethyl $[C(C_2H_5)_4O_4]$ (tetraethylorthocarbonic ester) was obtained.

——— (43)
NOTE ON THE ACTION OF CHLOROPICRIN AND CHLOROFORM ON ACETATE OF POTASH. Jour. Chem. Soc. [London] 18: 31–33. 1865.

Chloropicrin is decomposed with great readiness when heated to 100° C. in a closed vessel with fused potassium acetate and alcohol. Potassium chloride, potassium nitrite, potassium carbonate, ethyl acetate, and biacetate of potash are formed. On heating a mixture of 1 part of chloropicrin with 3 parts of aniline to 145° a violent reaction is established, carbotriphenyltriamine being formed.

——— (44)
ON A CYANOGEN-DERIVATIVE OF MARSH GAS. Jour. Chem. Soc. [London] 19: 352–355. 1866.

By the action of potassium cyanide upon chloropicrin in diluted alcohol the dinitrile of chloronitromalonic acid $(CCl(CN)_2NO_2)$ is obtained.

Baxter, G. P., Bezzenberger, F. K., and Wilson, C. H. (45)

THE VAPOR PRESSURES OF CERTAIN SUBSTANCES: CHLOROPICRIN, CYANOGEN BROMIDE, METHYL-DICHLORO-ARSINE, PHENYL-DICHLORO-ARSINE, DIPHENYL-CHLORO-ARSINE, AND ARSENIC TRICHLORIDE. Jour. Amer. Chem. Soc. 42: 1386–1393. 1920.

The vapor pressures were determined by the air current method; that is, by passing a known volume of air through a weighed receptacle maintained at constant temperature in a water thermostat, and calculating from the loss in weight of the saturating tube the volume of vapor, assuming that 1-g molecule under standard conditions occupies 22.41 liters. At 0° C. the vapor pressure of chloropicrin is 5.71 mm; at 20°, 18.31 mm; at 35°, 40.14 mm. The heat of vaporization of chloropicrin, expressed in kilogram calories per gram molecule, is 7.10 at 0° and 6.77 at 35°.

Bennett, G. M., and Mitchell, A. D. (46)

TOTALE OBERFLÄCHENERGIE UND CHEMISCHE KONSTITUTION. Ztschr. Phys. Chem. 84: 475–497. 1913.

The total surface energy of chloropicrin, calculated from data of Schiff (Ann. Chem. 223: 47–106. 1884), is 1535, and the theoretical value is 1558.

Berlingozzi, S. and Badolato, P. (47)

AZIONE DELLA CLOROPICRINA SUL FENOLO. Atti. R. Accad. Naz. Lincei, Rend. Cl. Sci. Fis., Mat. e Nat. (1) 33: 290–292. 1924.

The interaction of chloropicrin and phenol in the presence of potassium hydroxide results in the elimination of the nitro group, which effects oxidation and is itself reduced to ammonia. The principal products are o- and p-salicylic aldehyde, and the corresponding acids. Large quantities of p-rosolic acid are also formed, probably by condensation of the phenol with the salicylic aldehyde.

Bernes, J. (48)

DESTRUCTION DES SAUTERELLES ET DES CRIQUETS. Bibliotheque Vermorel no. 113, 48 p. Paris. 1923.

Reference is made to the work of Vayssiere against grasshoppers with an aqueous solution containing 10 percent chloropicrin and 20 percent coconut-oil soap. Only an experienced operator should manipulate this product (p. 29).

Berolzheimer, D. D. (49)

GASES USED IN WARFARE. REFERENCES TO THE STANDARD REFERENCE BOOKS. Jour. Indus. and Engin. Chem. 11: 256. 1919.

Refers to Beilstein's Handbuch, v. 1, p. 203, and sup. 1, p. 61; to Richter's Lexikon der Kohlenstoffverbindungen, v. 1. p. 41; and to Stelzner's Literature-Register der Organischen Chemie, 1910–11, p. 36, for literature on chloropicrin.

Bertrand, G. (50)

SUR LE HAUTE TOXICITÉ DE LA CHLOROPICRINE VIS-A-VIS DE CERTAINS ANIMAUX INFERIEURS ET SUR LA POSSIBILITÉ D'EMPLOI DE CETTE SUBSTANCE COMME PARASITICIDE. Compt. Rend. Acad. Sci. [Paris] 168: 742–744. 1919; Prog. Agr. et Vitic. 71: 376–378. 1919.

The following physical constants for chloropicrin are given: Density at 16° C., 1.666; boiling point at 766 mm, 112.3°; vapor pressure at 15°, 30.2 mm; 1 liter of water at 18° dissolves 1.65 g. Larvae of such Lepidoptera as *Sparganothis pilleriana* and *Polychrosis* [*Eudemis*] *botrana*, sawfly larvae, and aphids on Japanese spindlewood (*Euonymus*) were suspended in 1 or 2 liter flasks in which a known quantity of chloropicrin had been introduced and allowed to remain for 15 minutes before the introduction of the insects. An exposure of 5 to 10 minutes in an atmosphere containing only 0.01 to 0.02 g of chloropicrin per liter killed the insects in a short time. In solution in water chloropicrin is very toxic to infusoria and amoeba. Bertrand suggests the use of chloropicrin for fumigation and as a spray (in aqueous emulsion) against certain parasites of cultivated plants and for the partial sterilization of stools.

BERTRAND, G.—Continued. (51)

ACTION DE LA CHLOROPICRINE SUR LES PLANTES SUPÉRIEURES. Compt. Rend. Acad. Sci. [Paris] 170: 858–860. 1920.

The resistance of plants varies with the species, concentration of chloropicrin in the air, and duration of exposure. It is possible to kill the parasites on a plant with chloropicrin without killing the host.

——— (52)

DES CONDITIONS QUI PEUVENT MODIFIER L'ACTIVITÉ DE LA CHLOROPICRINE VIS-À-VIS DES PLANTES SUPÉRIEURES. Compt. Rend. Acad. Sci. [Paris] 170: 952–954. 1920.

Chloropicrin has the same effect upon plants in the dark as in diffused daylight; but in the direct sunlight, the injury is much greater. Humidity does not affect the activity of chloropicrin vapor on plants. The influence of temperature is very distinct. If the differences of treatment are not too great, the effects of chloropicrin are almost proportional to the concentration of the vapor and the duration of the exposure; that is, a 20-minute exposure to a concentration of 30 g gives the same result as a 30-minute exposure to 20 g. Tests were made with the leaves of the following species: Japanese spindle tree, black poplar, lilac, pear tree, elm, melilot, and golden daisy.

——— (53)

OBSERVATIONS SUR LE PROPRIÉTÉS DES SUBSTANCES LACRYMOGÈNES ET SUR LA MESURE DE LEUR ACTIVITÉ. Compt. Rend. Acad. Sci. [Paris] 171: 965–967. 1920.

Chloropicrin exerts an immediate effect on the eyes, whereas monochloroacetone has a progressive action. This difference is explained by a difference in solubility in water, the monochloroacetone being 80 times as soluble. The tear effect is produced a little less quickly in the morning than in the afternoon.

——— (54)

SUR L'ETOUFFAGE DES COCONS DE VERS À SOIE PAR LA CHLOROPICRINE. Compt. Rend. Acad. Sci. [Paris] 178: 1656–1660. 1924.

One gram of chloropicrin will suffocate 1 kg of silkworm cocoons in 1 hour at ordinary temperature. The yield of raw silk from cocoons treated with chloropicrin is equal, and sometimes superior, to that from cocoons treated with dry or moist heat.

——— (55)

RECHERCHES SUR L'ETOUFFAGE DES COCONS DE VERS À SOIE. ETUDE D'UN NOUVEAU PROCEDE A BASE DE CHLOROPICRINE. Ann. Sci. Agron. Franc. et Étrang. 41: 72–108. 1924; and Bul. Soc. Encour. Indus. Natl. [Paris] 136: 519–547. 1924.

Silkworm (*Bombyx mori*) cocoons are suffocated after 1 hour's exposure at a temperature of about 20° C. to chloropicrin vapor at the rate of 1 g per kilogram of cocoons. The yield of silk from cocoons killed by chloropicrin is equal to that obtained from cocoons killed by either dry or moist heat, and the physical properties of the silk are the same.

——— (56)

NOUVELLES EXPERIENCES SUR L'ETOUFFAGE DES COCONS DE VERS A SOIE PAR LA CHLOROPICRINE. TECHNIQUE ET CAMPAGNE DE 1925. Ann. Inst. Pasteur 40: 288–299. 1926.

Chloropicrin at the rate of 1 g to 1 kg of silkworm cocoons kills the pupae after 1 hour's exposure. This process is more convenient than the dry or moist heat process and does not injure the quality of silk. Results with chloropicrin in France and Morocco during 1925 are given.

——— and BROCQ-ROUSSEU. (57)

SUR LA DÈRATISATION PAR LA CHLOROPICRINE. Compt. Rend. Acad. Sci. [Paris] 170: 345–347. 1920.

Rats (*Mus decumanus* Pallas) exposed to a concentration of 1 g of chloropicrin per cubic meter died in 2½ hours, and those exposed to a concentration of 30 g per cubic meter died in 10 minutes. Rats exposed to a concentration of 10 g of chloropicrin per cubic meter for 1 minute

Bertrand, G.—Continued. (57)
SUR LA DÈRATISATION PAR LA CHLOROPICRINE—Continued.

and then withdrawn died in about 4 hours; exposed for 15 minutes to the same concentration and then withdrawn, rats died in 28 minutes. The temperature in these tests was around 15° C. The flea (*Ceratophyllus fasciatus* Bosc.) is more sensitive to chloropicrin than the rat, quitting its host when placed in an atmosphere of this substance. Placed in a concentration of from 5 to 30 g per cubic meter at a temperature of 16° to 24°, fleas died in from 3 to 15 minutes.

——— **Brocq-Rousseu, and Dassonville.** (58)
DESTRUCTION DE LA PUNAISE DES LITS (CIMEX LECTULARIUS MER.) PAR LA CHLOROPICRINE. Compt. Rend. Acad. Sci. [Paris] 169: 441–443. 1919.

In a concentration of 1 g of chloropicrin per cubic meter, bedbugs died in 12 hours and 22 minutes; in a concentration of 10 g per cubic meter, they died in 1 hour and 26 minutes; and in a concentration of 20 g per cubic meter, they died in 33 minutes. A room containing eight beds was sprayed with chloropicrin at the rate of 10 g per cubic meter (equivalent to 0.6 pound per 1,000 cubic feet) and after 4 hours all bedbugs were dead. If any of the eggs escape, the treatment should be repeated within 2 weeks.

——— **Brocq-Rousseu, and Dassonville.** (59)
DESTRUCTION DU CHARANCON PAR LA CHLOROPICRINE. Compt. Rend. Acad. Sci. [Paris] 169: 880–882. 1919.

In a concentration of 1 g of chloropicrin per cubic meter, the rice weevil (*Calendra* .[*Sitophilus*] *oryza* L.) died in 15 hours and 25 minutes; in a concentration of 30 g per cubic meter death took place in 53 minutes; the temperature ranged from 20° to 27°C. Weevils in grain were killed by pouring 20 to 25 g of chloropicrin over each sack. The sacks were in a closed building where the temperature was between 10° and 12°. Exposure for 20 hours was allowed.

——— **Brocq-Rousseu, and Dassonville.** (60)
INFLUENCE DE LA TEMPERATURE ET D'AUTRES AGENTS PHYSIQUES SUR LE POUVOIR INSECTICIDE DE LA CHLOROPICRINE. Comp. Rend. Acad. Sci. [Paris] 169: 1059–1061. 1919.

Experiments made principally with the weevil, but also with the bedbug and the cockroach, show that the action of chloropicrin is very much more rapid at high temperatures. By using a concentration of 20 g of chloropicrin per cubic meter, 4 hours were required to kill weevils at a temperature of 0° C.; at the same concentration the insects died in 31 minutes when the temperature was 37°. Tests made in air dried over calcium chloride and air saturated with water vapor show that humidity is without influence on the insecticidal power of chloropicrin. The insecticidal action of chloropicrin was the same in daylight as in darkness.

——— **Brocq-Rousseu, and Dassonville.** (61)
ACTION COMPARÉE DE LA CHLOROPICRINE SUR LA CHARANCON ET SUR LE TRIBOLIUM. Compt. Rend. Acad. Sci. [Paris] 169: 1468–1470. 1919.

Tribolium (*Tribolium navale* F.=*T. ferrugineum* F.) is more resistant to chloropicrin than *Calendra* [*Sitophilus*] *oryza*. In an 8-liter glass flask at 14° to 19° C., Tribolium withstood 1 g of chloropicrin per cubic meter for 40 hours, whereas *C. oryza* withstood it for only 15 hours. When the concentration was 30 g per cubic meter Tribolium died in 1 hour and 20 minutes; the corresponding time for *C. oryza* was 50 minutes.

——— and **Dassonville.** (62)
SUR LE TRAITEMENT DE LA GALE DES EQUIDES PAR LES VAPEURS DE CHLOROPICRINE. Compt. Rend. Acad. Sci. [Paris] 169: 486–489. 1919.

Chloropicrin is substituted for sulphur dioxide in the treatment of mange (gale) in horses. The horse is placed in a cabinet with only its head emerging, and chloropicrin at the rate of 20 g per cubic meter is sprayed in, direct spraying of the animal being avoided. The head of the horse is treated with an ointment composed of 100 g of vaseline and 2.5 g of chloropicrin. One half hour in the cabinet gives excellent results.

Bertrand, G., and Rosenblatt, M. (63)
ACTION TOXIQUE COMPARÉE DE QUELQUES SUBSTANCES VOLATILES SUR DIVERS INSECTES. Compt. Rend. Acad. Sci. [Paris] 168: 911–913. 1919.

Tests were made chiefly upon the larvae of *Bombyx neustria*, but also upon *Polychrosis* [*Eudemis*] *botrana*, a species of Noctuid, and the larva of a Tenthredinid on poplar. The insects were exposed to known concentrations of the vapors of the compounds for periods ranging from 10 minutes to 1 hour. Chloropicrin was the most toxic, followed by hydrocyanic acid. monochloroacetone, benzyl bromide, carbon disulphide, carbon tetrachloride, chloroform, and ether, in the order named.

——— and Rosenblatt, M. (64)
ACTION DE LA CHLOROPICRINE SUR LA LEVURE ET SUR LA FLEUR DU VIN. Compt. Rend. Acad. Sci. [Paris] 170: 1350–1352. 1920.

One milligram of chloropicrin in 1 liter of sugared must retards fermentation, and 5 to 6 mg stops fermentation entirely. Flower of wine is even more sensitive than yeast to the action of chloropicrin. One milligram per liter will prevent the growth of *Saccharomyces vini*. Wine passed through a porcelain filter fails to develop the flower in the presence of 0.2 mg of chloropicrin per liter.

——— and Rosenblatt, M. (65)
ACTION DE LA CHLOROPICRINE SUR QUELQUES FERMENTATIONS BACTERIENNES. Compt. Rend. Acad. Sci. [Paris] 170: 1468–1471. 1920.

Twenty to thirty mg of chloropicrin per liter stops lactic acid fermentation; 50 to 60 mg of chloropicrin per liter stops the ammoniacal fermentation of urine; and 0.1 mg of chloropicrin per liter stops all development of the bacteria of sorbose.

——— and Rosenblatt, M. (66)
LA CHLOROPICRINE AGIT-ELLE SUR LES FERMENTES SOLUBLES? Compt. Rend. Acad. Sci. [Paris] 171: 137–139. 1920.

Chloropicrin has only a feeble inhibitory action against the soluble ferments sucrase, amygdalinase, urease, catalase, zymase. laccase, and tyrosinase.

Bewad, J. (67)
DIE SYNTHESE VON MONONITROPARAFFINEN. Jour. Prakt. Chem. 48: 345–383. 1893.

By the action of zinc methyl upon chloropicrin, tertiary nitrobutane $[(CH_3)_3\,CNO_2]$ is obtained; by the action of zinc ethyl upon chloropicrin, nitroheptane $[(C_2H_5)_3CNO_2]$, secondary nitropentane $[(C_2H_5)_2CHNO_2]$, and primary nitropropane $[C_2H_5CH_2NO_2]$ are formed.

Bielouss, E. (68)
NITROCHLOR DERIVATIVES OF OPEN-CHAIN HYDROCARBONS AND PROCESS OF MAKING SAME. U.S. Patent 1,519,017, issued December 9, 1924; applied for July 30, 1921.

Claims the process of making nitrochlor derivatives of open-chain hydrocarbons which comprises subjecting a paraffin-type mineral oil distillate having specific gravity of not less than 0.882 successively to chlorination and nitration. These nitrochlor derivatives are readily miscible with nitrocellulose solutions, and either with or without nitrocellulose yield continuous varnish films on evaporation.

Billon, F. (69)
PURIFICATION OF VACCINES BY MEANS OF TRICHLORONITROMETHANE. French Patent 612,075, issued October 16, 1926; applied for June 6, 1925.

A very small addition of chloropicrin to the glycerine serving as diluent for the vaccine conserves the mixture.

Biltz, H., and Sedlatscheck, K. (70)
5-NITROBARBITURSAUREN. Ber. Deut. Chem. Gesell. 57: 339–349. 1924.

In the formation of chloro derivatives of 5-nitrobarbituric acid, chloropicrin is formed as a byproduct. Chloropicrin also results when these chloro derivatives are warmed with water.

BISHOPP, F. C., ROARK, R. C., PARMAN, D. C., and LAAKE, E. W. (71)
REPELLENTS AND LARVICIDES FOR THE SCREW WORM AND OTHER FLIES. Jour. Econ. Ent. 18: 776–778. 1925.

Chloropicrin, even in a dilution of 1 to 100, is highly repellent to the screw worm and other flies. Chloropicrin sprays for the horn fly, stable fly, and house fly on livestock have decided repellent value, but a satisfactory diluent has not yet been found.

BLASZKOWSKA-ZAKRZEWSKA, H. (72)
DETERMINATION OF VAPOR TENSION OF CHLOROPICRIN AT TEMPERATURES AROUND 100°. Rocz. Chem. 8: 210–218. 1928. [Abstract in Chem. Abs. 23: 1324. 1929.]

The vapor tension of chloropicrin was determined at 98° to 105° in Swientoslawski's ebullioscopic thermostat by the air-current method, which consists in determining from the loss of weight the quantity of substance carried away at a given temperature by a definite amount of air. The velocity of the air current was 300 cc per minute. The mean error was 0.6° to 0.8°. The values obtained were: 98°, 502.1; 100.0°, 532.0; 102.0°, 564.4; 103.0°, 567.6; 104.0°, 583.0; 105.0°, 597.0.

——— (73)
METHOD FOR THE DETERMINATION OF VAPOR TENSION OF VERY SMALL QUANTITIES OF SUBSTANCE. VAPOR TENSION OF CHLOROPICRIN. Rocz. Chem. 8: 219–228. 1928. [Abstract in Chem. Abs. 23: 1325. 1929.]

The immersed-bulb method permits determinations of vapor tension with 0.03 to 0.5 g. The following values were obtained for trichlornitromethane: 98.0°, 491.4; 100.0°, 524.3; 102.0°, 558.2; 103.0°, 577.9; 104.0°, 595.2; 105.0°, 612.8. The results differ considerably from those obtained by the air-current method and may be considered more trustworthy, because of the experimental errors inherent in the latter and because Avogadro's law, which underlies the calculations of vapor tension by the dynamic method, probably does not obtain for saturated vapors. The boiling point of trichlornitromethane, or chloropicrin, at a pressure of 760 mm of mercury is calculated to be 112.21° C.

——— (74)
ON THE RATE OF EVAPORATION OF LIQUIDS FROM A HEATED METAL SURFACE. Bul. Internatl. Acad. Polon. Sci. Lettres, ser. A, p. 188–190. 1930.

The relation between the time of evaporation of liquid drops and the temperature of a heated metal surface from which the liquid is evaporating was studied. It was found that for a given liquid and a given surface there exists a characteristic temperature of highest rate of evaporation, when the time of evaporation of a given quantity of liquid (for instance a drop) reaches its minimum.

The temperature of the maximum rate of evaporation of chloropicrin from a surface of aluminum bronze is about 140°.

BOEDTKER, E. (75)
SUR UN NOUVEL EFFET CATALYTIQUE DU CHLORURE D'ALUMINUM. Bul. Soc. Chim. France (4) 3: 726–729. 1908.

Chloropicrin and benzene react in the presence of aluminum chloride, forming triphenylmethane and triphenylcarbinol [$(C_6H_5)_3COH$].

BOLDYREFF, T. E. (76)
USE OF CHLOROPICRINE FOR DISINFECTION OF CLOTHES DURING WAR. Voy. Med. Jour. 2 (1): 43–52. 1931. [Listed in Quarterly Cumulative Index Medicus 10: 239 and 319. 1931.]

BOLDYREW, T. E. (77)
ÜBER DIE MÖGLICHKEIT DER ANWENDUNG VON CHLORPIKRIN FÜR DIE DESINFEKTION DER KLEIDUNG IN DER KRIEGSZEIT. Militär-Mwd.-Ztschr. [Russ.: Wojenno-Medizinskii Zhur.] 2: 43–52. 1931. [Abstract in Chem. Zentbl. 102 (II): 3119. 1931.]

Discusses the use of chloropicrin in disinfecting and delousing clothing.

Bouffard, G. (78)
LA CHLOROPICRINE DANS LA LUTTE CONTRE LA PESTS À MADAGASCAR. Bul. Soc. Path. Exot. 16: 602–605. 1923.

In Madagascar the rats in 8,000 houses have been killed in a month and a half with chloropicrin. Where the plague has been found chloropicrin is used at the rate of 15 g per cubic meter; in other places 5 g is used and the house is closed for 48 hours. Under favorable conditions chloropicrin kills rats in 24 hours when used at the rate of 2 g per cubic meter.

Boyd, W. J. (79)
NOTE ON THE ACTION OF MIXTURES OF NITRIC AND HYDROCHLORIC ACIDS ON ACETONE. Jour. Soc. Chem. Indus. 44: 222T. 1925.

By the addition of acetone to a warmed mixture of hydrochloric and nitric acids, chloropicrin, dichlorodinitromethane, and monochlorotrinitromethane are formed. The relative proportions of these vary with the temperature of the reaction and the proportions of hydrochloric and nitric acids.

Braemer, P., and Bloch, A. (80)
LA DESINSECTISATION PAR LA CHLOROPICRINE. TRAITEMENT DES SEMENCES DE MAIS. Bul. Econ. Indochine 27: 261–265. 1924.

Maize seed badly infested with weevils was treated with 20 cc of chloropicrin per 35 cubic feet for 24 hours. It was free from weevils after 45 days, when examined. The germinating power was reduced. The same dose applied for 12 and 18 hours seemed to kill adults and larvae of *Calendra* [*Sitophilus*] *oryza* but not the eggs; weaker doses apparently killed the adults only. Sacks of flour infested with weevils and tobacco infested with Anobiids were successfully treated with chloropicrin at the rate of 5 cc per 35 cubic feet. No disagreeable flavor was left in the products.

British Dyestuffs Corporation, Ltd., and Lefebure, V. (81)
IMPROVEMENTS IN OR RELATING TO INSECTICIDES AND THE LIKE, THEIR MANUFACTURE AND USE. British Patent 225,262, issued December 24, 1924; applied for August 2, 1923.

The patentees claim the manufacture of materials suitable for use as insecticide by preparing a readily decomposable double compound of chloropicrin or 1-2-4-chloro-dinitro benzene with ammonia, pyridine, aniline, or o-toluidine in the presence of an absorbing agent, such as silica gel or charcoal.

Browne, C. A. (82)
REPORT OF THE CHEMIST FOR 1924. U.S. Dept. Agr. Bur. Chem. Ann. Rpt. 26 p. 1924.

Experiments made with goats and cattle on the ranges have shown that small quantities of chloropicrin in mineral oil, or in pine-tar oil, are very effective in repelling flies, and that wounds treated with the mixture appear to heal rapidly (p. 12).

Brühl, J. W. (83)
SPEKTROCHEMIE DES STICKSTOFFS. Ztschr. Phys. Chem. 16: 193–225. 1895.

A sample of chloropicrin from Kahlbaum, dried over calcium chloride and distilled at 111° to 111.5° C. under 750.2 mm pressure, showed the following: Specific gravity $\frac{20^\circ}{4^\circ}$, 1.6539; specific gravity $\frac{22.8^\circ}{4^\circ}$, 1.6511; refractive index, n at 22.8°, 1.45740 (Li), 1.45793 (Ha), 1.46075 (Na), 1.46393 (Tl), 1.46785 (Hb), 1.45377 (Hg).

Bruner, L. (84)
UEBER NITROMETHAN ALS LÖSUNGSMITTEL. Ber. Deut. Chem. Gesell. 36: 3297-3298. 1903.

The specific conductivity of chloropicrin was found to be at least 10 times less than that of nitromethane.

BRUNETEAU, J. (85)
LES TEIGNES DES VETEMENTS. Rev. Zool. Agr. et Appl. 29 (10): 149–159. 1930.

Chloropicrin at the rate of 15 g per cubic meter killed 100 percent of the eggs, larvae, and adults of *Trichophaga tapetzella* L. exposed to it at 22° C. for 24 hours (p. 157).

BRUNI, G., and BERTI, P. (86)
SUL COMPORTAMENTO CRIOSCOPICO DEI NITRODERIVATI SCIOLTI IN ACIDO FORMICO. Atti R. Accad. Naz. Lincei, Rend. Cl. Sci. Fis., Mat. e Nat. 9: 273–279. 1900.

The molecular depression of the freezing point of chloropicrin in formic acid ranged from 25.7 to 27.4, indicating no dissociation.

BURKHARDT, F. (87)
ERFAHRUNGEN MIT DEM CHLORPIKRIN ALS MITTEL ZUR BEKÄMPFUNG TIERISCHER SCHÄDLINGE. Deut. Landw. Presse 47: 447. 1920.

The minimum lethal concentration of chloropicrin for *Calendra granaria* is 4 g per cubic meter, the exposure being 24 hours.

BUSINCO, A. (88)
I GAS COSI DETTI "ASFISSIANTI" IN GUERRA. Riv. Med. Leg. 6: 259–266, 279–287, 305–312, 337–343. 1916.

Chloropicrin is a lachrymatory gas and irritates the respiratory mucosa (p. 342). The gases used during the war are listed.

——— (89)
I GAS COSI DETTI "ASFISSIANTI." Gior. Med. Mil. 69: 436–508. 1921.

Chloropicrin with diphosgene was used by Germany and her allies, and chloropicrin with acquinite by France and Italy in the war as asphyxiating and lachrymatory gases (p. 438). The effects of chloropicrin poisoning are described (p. 465–7). The action of a mixture of phosgene and chloropicrin is described (p. 476). A bibliography on asphyxiating gases is appended.

C., M. (90)
L'EMPLOI DE LA CHLOROPICRINE POUR LA DESTRUCTION DES PARASITES ET SON ACTION SUR LES PLANTES. Rev. Vitic. 52 (1352): 369. 1920.

An account of the work of Bertrand and of Piutti and Bernardini with chloropicrin as a fumigant.

CAHOURS, A. (91)
ANALYSE DE LA CHLOROPICRINE. Compt. Rend. Mens. Trav. Chim. 5: 170. 1849.

An analysis of a sample of chloropicrin boiling between 114° and 115° C. gave carbon, 7.09 and 7.19 percent, and chlorine, 64.59 percent. This agrees with the percentages required in the formula CCl_3NO_2 suggested by Gerhardt, namely, carbon, 7.2 percent, and chlorine, 65.0 percent.

CARMOUZE. (92)
NOTICE SUR L'UTILISATION DE LA CHLOROPICRINE POUR LA DESTRUCTION DES FOURMIS-MANIOC. Ann. Med. Pharm. Col. 26: 460–463. 1929. [Abstract in Rev. Appl. Ent. (A) 18: 224. 1930.]

Chloropicrin was successfully used in the control of ants [*Atta*]. attacking cassava and other crops in French Guiana, all stages being destroyed by the injection of 200 cc into the nest by means of a funnel. The ease and rapidity with which the injection is made renders the use of a mask unnecessary.

CATTON, J. (93)
GAS WARFARE—ITS AFTERMATH. Mil. Surg. 45: 65–74. 1919.

Author lists chloropicrin with phosgene, diphosgene, and chlorine as a suffocant gas (p. 65). Action of phosgene is described in detail.

CHAPMAN, R. N. (94)
INSECTS INFESTING STORED FOOD PRODUCTS. Minn. Agr. Expt. Sta. Bul. 198: 71. 1921.

Chloropicrin is superior to carbon disulphide for fumigating grain, etc., and penetrates flour much better. Only 1 to 2 pounds per 1,000 cubic feet is required. Chloropicrin has some detrimental effect upon the baking qualities of flour and is very irritating to the skin. Because of its weight, it is difficult to ventilate a place that has been fumigated with it.

——— (95)
THE USE OF CARBON TETRACHLORIDE EITHER ALONE OR IN COMBINATION WITH PARADICHLOROBENZENE OR CHLOROPICRIN FOR FUMIGATING GRAIN IN ELEVATORS. Minn. Agr. Expt. Sta. Ann. Rpt. 30: 68. 1922.

Chloropicrin is mentioned in the title only.

——— (96)
FUMIGANT. U.S. Patent 1,502,174, issued July 22, 1924; applied for December 15, 1923.

Chapman claims a fumigant consisting of carbon tetrachloride and chloropicrin in equal parts by volume. This mixture is stated to have the toxic attribute of chloropicrin and the volatility attribute of carbon tetrachloride.

——— and JOHNSON, A. H. (97)
POSSIBILITIES AND LIMITATIONS OF CHLOROPICRIN AS A FUMIGANT FOR CEREAL PRODUCTS. Jour. Agr. Research [U.S.] 31: 745–760. 1925.

In experiments with the granary weevil (*Calendra granaria* L.) in 8-liter glass jars, no relationship was found to exist between relative humidity and toxicity of chloropicrin vapor, but an inverse relationship between the time and concentration holds. Chloropicrin sprayed as a fine mist in a room at the rate of 32 g per cubic meter killed all adults, larvae, and pupae of the Indian meal moth (*Plodia interpunctella* Huebn.). Water saturated with chloropicrin (1.65 g per liter at 18° C.) retards yeast activity, 5 cc of this chloropicrin solution completely stopping yeast activity in 50 cc of a 3 percent yeast suspension. Chloropicrin decreases the water-holding capacity of gluten and destroys its elasticity and tenacity. Chloropicrin effects no significant change in hydrogen ion concentration of dough suspensions. Chloropicrin lowers the viscosity of flour. Flour retains chloropicrin vapor for a long time. Bread made from chloropicrin-fumigated flour was injuriously affected, the volume of the loaf being less than one half that made from unfumigated flour. On standing for a month in a cloth sack the fumigated flour regained nearly all its baking qualities. Wheat fumigated with chloropicrin at the rate of 5 pounds per 1,000 cubic feet, yields a flour with poor baking qualities, but on exposure to the air for 10 days the wheat almost entirely recovers from the treatment. Bread made from flour fumigated with carbon disulphide gave a loaf of 1,200 cc, as compared with a volume of 1,580 cc for a loaf from untreated flour.

CHATTAWAY, F. D., and HARRISON, J. M. (98)
THE INTERACTION OF TETRANITROMETHANE AND POTASSIUM FERROCYANIDE. Jour. Chem. Soc. [London] 109: 171–174. 1916.

Chloropicrin has no action on a solution of potassium ferrocyanide. In a saturated aqueous solution potassium ferrocyanide reacts with tetranitromethane as follows:

$C(NO_2)_4+2K_4Fe(CN)_6=C(NO_2)_3K+KNO_2+2K_3Fe(CN)_6$ (p. 172).

CHAVIGNY, P. (99)
LES ANIMAUX PARASITES DE L'HOMME ET DE L'HABITATION CE QUE TOUT LE MONDE DOIT EN SAVOIR. 407 p. Paris. 1924.

The fumigation of a ship at Marseilles in 1922 with chloropicrin for the destruction of rats is referred to (p. 83). For the destruction of body lice in clothing, fumigation with chloropicrin is recommended (p. 208).

CHLOPIN. (100)

MILITÄRISCHE UND SANITÄRE GRUNDLAGEN DES GASSCHUTZES. Ztschr. Gesam. Schiess u. Sprengstoffw. 22: 227–230, 262–266, 297–302, 333–336, 369–372. 1927; and 23: 29–33. 1928.

Chloropicrin is included in a chemical and physiological classification of war gases. General characteristics of chloropicrin, the countries using it, and the method of using it are given. The relative toxicity of the war gases as compared to chlorine is given; chloropicrin is 2.2 times as toxic as chlorine. The effect of fumigation with chloropicrin and chlorine on meat, tallow, bread, barley, flour, oats, snuff, and smoking tobacco is noted. A rat fed the meat and barley and another fed the tallow and flour showed no harmful effects. Chloropicrin has no harmful action on meat, tallow, oats, and tobacco. Apparatus, materials, and methods for guarding against chloropicrin are discussed.

COFFEY, W. C. (101)

ENTOMOLOGY AND ECONOMIC ZOOLOGY. Minn. Agr. Expt. Sta. Ann. Rpt. (1932–24) 32, pt. 1, 8 p. 1924.

One of the experiment station projects for 1923–1924 in entomology and economic zoology is the use of carbon tetrachloride, either alone or in combination with paradichlorobenzene or chloropicrin, for fumigating grain in elevators under the direction of R. N. Chapman (p. 26).

COLOMBO, G. (102)

LA SOFFOCAZIONE DEI BOZZOLI CON LA CLOROPICRINA. Gior. Chim. Indus. et Appl. 7: 15–17. 1925.

A discussion of the use of chloropicrin for suffocating silkworm cocoons. Chloropicrin is dangerous to handle and darkens the silk, and the process is not applicable to small producers who already have small, simple, economical, and easily transportable dryers.

COPISAROW, M. (103)

TRINITROTOLUENE RESIDUES AND THEIR UTILISATION. Chem. News 118: 13–14. 1918.

Chloropicrin can be obtained by treating TNT residues with bleaching powder. The yield compares favorably with that obtained by the degradation of picric acid residues, allowing for the percentage of nitrogen.

CORNUBERT, R. (104)

LA GUERRE DES GAZ. Rev. Gen. Sci. 31: 46, 52. 1920.

Chloropicrin was first used by the Germans in May 1917, and by the French toward the end of 1916.

COSSA, A. (105)

SULLA CLOROPICRINA. Gaz. Chim. Ital. 2: 181–184. 1872.

Chloropicrin was prepared by the action of chloride of lime upon picric acid in aqueous solution. (Chloropicrin dissolves iodine, cinnamic acid, benzoic acid, resins, etc.) It is miscible in all proportions with benzene, amyl alcohol, carbon disulphide, and absolute alcohol. At 11° C. 1 volume of 80.5 percent alcohol dissolves 3.7 volumes; 1 volume of 78 percent alcohol, 1.3 volumes; and 1 volume of ether dissolves 0.3 volume. Chloropicrin boils at 112.8° C. under a pressure of 743 mm. It distills completely without decomposing.

COTTON, A., and MOUTON, H. (106)

NOUVEAUX CORPS PRESENTANT LA BIRÉFRINGENCE MAGNÉTIQUE. Anisotropie moléculaire et atomique. Compt. Rend. Acad. Sci. [Paris] 154: 930–933. 1912.

Chloropicrin has a positive magnetic birefringence ($b_s = +2$).

——— and MOUTON, H. (107)

BIRÉFRINGENCE MAGNÉTIQUE ET CONSTITUTION CHIMIQUE. Ann. Chem. et Phys. (8) 28: 209–243. 1913.

Data on chloropicrin are given (p. 236). The density is 1.65 and the specific magnetic birefringence has the value +2.

COTTON, R. T. (108)

CARBON DIOXIDE AS AN AID IN THE FUMIGATION OF CERTAIN HIGHLY ADSORPTIVE COMMODITIES. Jour. Econ. Ent. 23: 232-233. 1930.

The experiments were conducted in small vacuum tanks 8.7 and 21.76 liters in capacity. The insects used were adults of the confused flour beetle, *Tribolium confusum*, put up in cotton-stoppered vials. This species was chosen because it is more resistant to the gases used than any of the common pests of stored nut meats. The insects were placed as near as possible to the center of canvas bags filled with raw peanuts. Each bag held approximately 2½ pounds of peanuts, and in all fumigations the vacuum tanks were filled to capacity with these bags. Four glass vials, each containing 10 insects, were used in each test. In all experiments the temperature was approximately 72° F.

In an empty vacuum tank it required 2 ounces of chloropicrin per 100 cubic feet of space to give a 100 percent kill of *Tribolium confusum* adults in 2 hours at a temperature of 72°. When the tank was filled to capacity with raw peanuts it was found impossible to obtain a 100 percent kill in 2 hours even when a dose of 48 ounces per 100 cubic feet was used.

In an endeavor to obtain a kill in 2 hours with a reasonable amount of chloropicrin, tests were made with various mixtures of chloropicrin and carbon dioxide.

After the customary 27 inches of vacuum was drawn the carbon dioxide was admitted to the tank, followed immediately by the chloropicrin.

It was found that up to a certain point, the more carbon dioxide that was used the less chloropicrin was required to give a kill. When used with carbon dioxide at the rate of 2.8 pounds per 100 cubic feet of space 7 ounces of chloropicrin gave a 100 percent kill of *Tribolium confusum* adults in 2 hours with the tank filled with raw peanuts. With 4.2 pounds of carbon dioxide per 100 cubic feet, 4 ounces of chloropicrin per 100 cubic feet gave a 100 percent kill.

Experiments in an empty vacuum tank with a 30-minute exposure at 72° indicated that the addition of carbon dioxide up to approximately 4.2 pounds per 100 cubic feet of space adds to the toxicity of chloropicrin in proportion to the amount of carbon dioxide used. Higher percentages of carbon dioxide apparently do not increase the toxicity of chloropicrin beyond this point. To summarize the experiments briefly, a 100 percent kill of *Tribolium confusum* was obtained in 30 minutes, with 6.6 ounces of chloropicrin per 100 cubic feet when used alone; with 4.6 ounces of chloropicrin when used with 1.4 pounds of carbon dioxide per 100 cubic feet; with 2 ounces of chloropicrin when used with 2.8 pounds of carbon dioxide per 100 cubic feet and with 1.28 ounces of chloropicrin when used with 4.2 or more pounds of carbon dioxide per 100 cubic feet of space.

——— and YOUNG, H. D. (109)

THE USE OF CARBON DIOXIDE TO INCREASE THE INSECTICIDAL EFFICACY OF FUMIGANTS. Ent. Soc. Wash. Proc. 31: 97–102. 1929.

In the first series of experiments, fumigation tests were conducted with specimens of the confused flour beetle, *Tribolium confusum* Duv., in 6-liter glass flasks.

With chloropicrin the results were striking. When used alone at the rate of 17 mg per liter a 100 percent kill was obtained in 90 minutes, whereas with the addition of 330 mg per liter of carbon dioxide the necessary exposure to kill 100 percent of the flour beetles was reduced to 20 minutes, or less than a fourth of the time.

CRAWFORD, F. A. F. (110)

ORGANIC IMPURITIES IN COMMERCIAL NITRIC ACID AND THEIR EFFECT IN THE MANUFACTURE OF NITROGLYCERIN. Jour. Soc. Chem. Indus. 41 (18) : 321T–324T. 1922.

An oil has been isolated from commercial nitric acid and has been shown to be composed of a mixture of tetranitromethane, monochlorotrinitromethane, dichlorodinitromethane, and possibly a trace of chloropicrin.

The formation of these compounds is probably due to the presence of traces of chlorides and of organic matter in the sodium nitrate from which the nitric acid is made, and these substances are therefore probably present to a greater or less extent in all samples of commercial nitric acid. Dichlorodinitromethane and chloropicrin in small concentration have no effect on the heat test of nitroglycerin.

DATTA, R. L. and CHATTERJEE, N. R. (111)
THE PRODUCTION OF CHLOROPICRIN BY THE ACTION OF AQUA REGIA ON ORGANIC COMPOUNDS. (PRELIMINARY PAPER.) Jour. Amer. Chem. Soc. 37: 567–569. 1915.

Aqua regia is a chlorinating as well as an oxidizing agent. It sometimes acts destructively, leading to the rupture of organic substances subjected to its action, with the production of chloropicrin. When acetone is gradually added to 10 parts of a slightly warmed mixture of 2 parts of nitric acid and 3 parts of hydrochloric acid, warmed for some time on the water bath and steam distilled, 85 percent of chloropicrin is obtained. When the reaction is carried out with warming, the production of chloropicrin from allyl alcohol is complete. Formic and acetic acids and methyl alcohol do not react with aqua regia; ether and ethyl alcohol are partly decomposed.

——— and CHATTERJEE, N. R. (112)
HALOGENATION. XII. THE FORMATION OF CHLOROPICRIN AND TETRACHLOROQUINONE BY THE ACTION OF AQUA REGIA ON ORGANIC SUBSTANCES. Jour. Amer. Chem. Soc. 38: 1813–1821. 1916.

Whenever an organic compound breaks up destructively under the influence of aqua regia, chloropicrin is produced.

——— and FERNANDES, F. V. (113)
HALOGENATION. XI. CHLORINATION WITH AQUA REGIA. THE CHLORINATION OF HYDROCARBONS. Jour. Amer. Chem. Soc. 38: 1809–1813. 1916.

Hydrocarbons which undergo decomposition under the influence of aqua regia, such as cymene, styrene, amylene, diisobutylene, and triisobutylene, give chloropicrin.

DEAN, G. A., and SCHENK, G. (114)
THE CONTROL OF STORED GRAIN AND FLOUR MILL INSECTS. Fourth Internatl. Cong. Ent. Trans. 2: 203–228. 1929.

" One executive of a nationally known milling company stated he has repeatedly sent samples of untreated checks and flours treated in their fumigatorium with chloropicrin to the laboratory for baking tests, and no deleterious effect had been noted. Recently a warehouse, owned by this same company, well filled with flour and feeds, was fumigated with chloropicrin at the rate of one pint for each 700 cubic feet of space. Inspection after this fumigation showed very poor results and indicated either a rapid escape of the gas, poor diffusion, or both.

" One Kansas miller used chloropicrin during June 1928 as a general mill fumigant. Eighty-eight pounds of the fumigant were sprinkled into the elevator legs and other machinery while the machinery was in motion. This amount of chloropicrin was used to treat 133,584 cubic feet of space. The exposure was about 18 hours. The mill had been previously cleaned and sealed according to general fumigation instructions.

" Inspection of this mill, made about five weeks after fumigation, showed that excellent results were obtained.

"Although there are conflicting reports on chloropicrin as a general mill fumigant and its effect on the baking qualities of the flour, its high toxicity and penetrating properties are such that it should be developed to its full possibilities as a mill fumigant (p. 223).

" Chloropicrin as a fumigant.—Chloropicrin is being used by some millers for vault-fumigation purposes and excellent penetration and kills are being secured at the rate of one pint of chloropicrin for 700 cubic feet of space. Due to the odor of chloropicrin and the irritating effect of the gas remaining for long periods, this fumigant is not being used for package goods, or other products to be marketed without reconditioning.

" Since good penetration is secured and since there is little or no difference in effectiveness between this fumigant and HCN, it is possible that it will become commonly used for the fumigation of returned bags and infested flour. However, some work remains to be done to clear up the question of the effect of chloropicrin upon the baking qualities of the flour " (p. 225).

Reference is made to work of Chapman (*94*), Chapman and Johnson (*97*), and Strand (*458*, *459*).

DECKERT, W. (115)
ÜBER DEN NACHWEIS UND DIE BESTIMMUNG VON CHLOROPICKRINDÄMPFEN IN LUFT. Ztschr. Hyg. u. Infektionskrank. 109: 485–490. 1929.

Chloropicrin turns test paper impregnated with a 5 to 10 percent solution of dimethylaniline in benzol a clear yellow to a dark brown, according to the concentration. For a quantitative determination the mixture of air and chloropicrin vapor is passed through a spiral wash flask containing glacial acetic acid. The absorbed chloropicrin is reduced with iron, and chlorine is determined in the filtrate by the Volhard method.

By another method the gas mixture is passed through a glass tube containing potassium carbonate and heated to 300 to 500° C., and the potassium chloride formed is determined by the Volhard method.

DELASSUS (116)
LA CHLOROPICRINE ET SON EMPLOI POUR LA DESTRUCTION DES PARASITES ANIMAUX. Rev. Agr. Afrique Nord 20: 78–81. 1922.

Review of the work of Bertrand, Miege, Vayssiere, Trouvelot, and Schindler.

DEMOREST, D. J. (117)
THE CHEMICAL ENGINEERING OF POISON GAS MANUFACTURE. Ohio State Engin. 2: 10–12, 28–29. 1919.

Chloropicrin (p. 11) was prepared at Edgewood Arsenal, Edgewood, Md., by mixing a cream of bleaching powder with a mixture of picric acid, water, and lime in a still about 8 feet in diameter and 15 feet high. Steam was introduced, and the chloropicrin formed was distilled over, condensed, separated from water, and loaded into shells. One hundred tons of bleach was used per day. It required about 600 horsepower of steam to produce 25 tons of chloropicrin per day.

DESGREZ, G., and LABAT (118)
SUR L'EMPLOI DES POLYSULFURES ALCALINS POUR NEUTRALISER CERTAINS GAZ TOXIQUES. Compt. Rend. Acad. Sci. [Paris] 172: 342–344. 1921.

Chloropicrin, chloramine, chlorine, carbonyl chloride, acrolein, bromoacetone, benzyl bromide, benzyl iodide, methyl chloride chloroformate ($ClCOOCH_2Cl$), and diphosgene, as well as mixtures of these, are removed from the atmosphere by spraying with a solution of sodic liver of sulphur (240 g), soapmaker's lye (140 cc) and water up to 1 liter, which is diluted by the addition of 10 liters of water at the time of spraying. Fifteen liters of this spray will remove 5 g of chloropicrin vapor in a space of 20 cubic meters. Commercial liver of sulphur is variable; the kind recommended contained 18.24 percent of sulphur as polysulphide, 4.74 percent of anhydrous hyposulphite, and 17.13 percent of anhydrous sulphate.

——— and SAVÈS (119)
SUR L'ASSAINISSEMENT DE L'AIR SOUILLÉ PAR CERTAINS GAZ TOXIQUES. Compt. Rend. Acad. Sci. [Paris] 171: 1177–1179. 1920.

Chloropicrin is removed from the atmosphere by spraying with a solution of sodic liver of sulphur (240 g), soapmaker's lye (140 cc) and water to 1 liter, which is diluted with 10 liters of water at the time of using. This spray is effective against chlorine, phosgene, methyl chloride chloroformate ($ClCOOCH_2Cl$), diphosgene, acrolein, bromoacetone, cyanogen chloride, and the iodide, bromide, and chloride of benzyl.

DEUTSCHE GOLD- UND SILBER-SCHEIDEANSTALT VORMALS ROESSLER IN FRANKFURT A. MAIN. (120)
REIZSTOFF FÜR GIFTIGE GASE ODER DÄMPFE. Austrian Patent 112,343, issued February 25, 1929; applied for July 18, 1925.

Chloropicrin is used as a tear gas in combination with poisonous gases or vapors that are not easily noticeable, such as hydrocyanic acid.

——— (121)
SCHÄDLINGSBEKÄMPFUNGSMITTEL. German Patent 517,631, issued February 9, 1931; applied for July 21, 1925.

An insecticide that consists of hydrocyanic acid containing sufficient chloropicrin to produce a tear-gas effect is described.

DEUTSCHE GOLD- UND SILBER-SCHEIDEANSTALT VORMALS ROESSLER IN FRANKFURT A. MAIN—Continued. (122)

VERFAHREN ZUR KENNTLICHMACHUNG VON WENIG ODER GAR NICHT WAHRNEHMBAREN GIFTSOFFEN DURCH WARN- ODER REIZSTOFFE. German Patent 524261, issued May 12, 1931; applied for January 17, 1928.

Two tear gases are added to hydrocyanic acid. One of these is a quickly diffusing gas, for example, cyanogen chloride or cyanogen bromide, and the other is a difficultly volatile slowly diffusing warning agent, for example, chloropicrin, bromoacetophenone, and bromoacetic acid ester.

DINGLER, M. (123)

ÜBER VERSUCHE MIT SPRENGUNGEN ZUR ENGERLINGSBEKÄMPFUNG. Ztschr. Angew. Ent. 8: 421–426. 1922.

Tests with cyanester, zyklon (cyanogen chloride), K2-stoff (phenylisonitrildichloride, $C_6H_5NCCl_2$), and chloropicrin in destroying the larvae of May beetles (*Melolontha*) in the ground are described. The experiments were made by blasting with explosives, used both alone and with the addition of the poisons, but in all cases unsatisfactory results were obtained. This appears to be due to the depth below the level where the larvae occur at which it was necessary to lay the charges in order that their effect should not be uselessly expended in the air. A useful result would be attainable only with charges that act chiefly in a horizontal plane and that are placed at a very slight depth. The addition of gaseous poisons is useless, because, apart from the resistance of the larvae, the earth is very impermeable, especially where it has been compressed by an explosion.

DOANE, R. W. (124)

COMMON PESTS. 384 p., illus. Springfield, Ill., 1931.

Chloropicrin is briefly referred to as a fumigant which has been used to destroy insects in stored grains and for treating clothing infested with vermin (p. 121).

DOUGHTY, H. W. (125)

HYDROLYSIS OF ORGANIC HALIDES AND THE CORROSION OF METALS. Jour. Amer. Chem. Soc. 39: 2685–2692. 1917.

Chloropicrin causes copper to dissolve rapidly in concentrated ammonia water (p. 2689).

——— (126)

THE ACTION OF CUPROUS CHLORIDE WITH COMPOUNDS CONTAINING THE TRICHLOROMETHYL GROUP. Jour. Amer. Chem. Soc. 41: 1129–1131. 1919.

A few milligrams of chloropicrin is placed in a small glass-stoppered bottle of 10 to 15 cc capacity. The bottle is then filled with concentrated ammonia water, and about 0.5 g of powdered cuprous chloride is added. The stopper is then quickly inserted, thus forcing out excess of liquid and excluding air . A green solution, changing to dark blue in 2 to 3 minutes, and a yellow precipitate are formed.

DOUGLAS, C. G. (127)

GAS POISONING IN WARFARE: THE TASK OF THE MEDICAL SERVICE. Jour. Roy. Army Med. Corps. 35: 79–92. 1920.

Chloropicrin is classified as an acute lung irritant. It was used by the Germans in shells from July 1916 to July 1917. From July 1917 until the end of the war it was mixed with phosgene, diphosgene, and, in some cases, chlorarsines in green cross shells.

DOWELL, C. T. (128)

CORN FUMIGATION. La. Agr. Expt. Sta. Rpt. 1929–31: 88–89. 1932.

Rice weevils (*Calendra* [*Sitophilus*] *oryzae* L.) and other grain pests cause the destruction of nearly 10 percent of the corn produced in Louisiana. Carbon disulphide applied at temperatures well above 60° F. at a dosage of at least 20 pounds per 1,000 cubic feet is recommended for fumigating cribs which have been made tight by lining with sheets of galvanized iron.

Preliminary tests of orthodichlorobenzene and of chloropicrin indicate that these materials are promising as grain fumigants.

DUBININ, M. M., SSOLOWJEW, L. A., and SCHILIN, G. K. (129)
ÜBER GASADSORPTION AUS STRÖMENDER LUFT. III. ÜBER EINE NEUE REGISTRIERUNGS-METHODE DES GASDURCH-STRÖMUNGSPUNKTES BEI UNTERSUCHUNG DER DYNAMISCHEN AKTIVITÄT VON ADSORBENTIEN. Jour. Russ. Phys.-Chem. Gesell. 62: 1953–1956. 1930. [In Russian. Abstract in Chem. Zentbl. 102 (I): 3663. 1931.]

The dynamic activity of absorbent charcoal has in the past been determined by passing chloropicrin through the adsorbent, and then through a quartz tube at 600 to 700°, after which the liberated Cl_2 was determined with KI and starch. This method is unsatisfactory for low concentrations of Cl_2.

The method was modified by placing a strip of KI-starch paper at the end of the exit tube in a gas-washing bottle. This strip touches the bottom of the washing bottle containing some starch iodine solution, but the exit glass tube is not allowed to touch the surface of the liquid. Mere traces of chlorine can be detected by the blue color of the starch-KI strip.

DUFRAISSE, C., and BONGRAND, J. C. (130)
LA MESURE DU POUVOIR LACRYMOGÉNE DES SUBSTANCES IRRITANTES PAR LA MÈTHODE DU SEUIL. Compt. Rend. Acad. Sci. [Paris] 171: 817–819. 1920.

Pure benzyl bromide is taken as a standard with a lachrymatory value of 1. The threshold concentration is that which is just felt by the eyes after exposure for 30 seconds. Tested in this way, the following values were determined: Benzyl bromide, 1; benzyl iodide, 2; bromoacetone, 1.8; dibromomethyl ether (oxyde de methyle dibrome symetrique), one fourth; chloropicrin, one sixth; chloroacetone, one eighth; acrolein, one tenth.

DUJARDIN-BEAUMETZ. (131)
LA DERATISATION. RAPPORT SUR LA DERATISATION AU NOM DE LA COMMISSION SPECIALE. Ann. Hyg. Pub. Ind. Soc. (n.s.) 1: 124–144. 1923.

Refers to the tests of Bertrand and Brocq-Rousseu. Rats in burrows were killed by injecting a few cubic centimeters of chloropicrin in each hole, and then carefully plugging the entrance with earth (p. 137).

DUMONT. (132)
POUR DETRUIRE LES SAUTERELLES. Vie Agr. et Rurale 9 (19): 331–332. 1920.

Reviews the work of Vayssiere in controlling grasshoppers in Crau. Spraying with aqueous emulsions of 25 percent, or better, 50 percent, chloropicrin has given excellent results.

EGASSE, C. (133)
LA DESTRUCTION DES INSECTES DANS LES MAGASINS ET ENTREPOTS DE CEREALES. Defense Agr. 23: 377–378. 1926.

This is a rather full abstract of the article by A. Piedallu (*361*).

ENGEL, E. (134)
ÜBER ADSORPTION DURCH AKTIVE KOHLE. Ztschr. Gesam. Schiess u. Sprengstoffw. 24: 451–454; 495–497. 1929.

The adsorption of different concentrations of chloropicrin vapor by four different charcoals was studied.

EVANS, W. V., and DUFFORD, R. T. (135)
LUMINESCENCE OF COMPOUNDS FORMED BY THE ACTION OF MAGNESIUM ON PARA-DIBROMOBENZENE AND RELATED COMPOUNDS. Jour. Amer. Chem. Soc. 45: 278–285. 1923.

Chloropicrin increased the luminescence of phenylmagnesium iodide, but not that of phenylmagnesium bromide, para-bromophenylmagnesium bromide, or para-iodophenylmagnesium iodide.

FABRE, G. (136)
PROCEDE ET APPAREIL POUR LA STERILISATION DES CHAMPIGNONS COMESTIBLES. French Patent 675,462, issued February 11, 1930; applied for May 21, 1929.

An apparatus for the fumigation of mushrooms is described. Chloropicrin is preferred as the fumigant in place of carbon disulphide, hydrogen cyanide, carbon tetrachloride, or sulphur dioxide. Chloropicrin is used at a dosage of 30 to 35 mg per liter with an exposure not exceeding 8 hours.

FAES, H. (137)
STATION FÉDÉRALE D'ESSAIS VITICOLES À LAUSANNE ET DOMAINE DE PULLY. Rap. ann. 1929. Ann. Agr. Suisse 31: 287–318. 1930.

Bruchids (*Acanthoscelides obtectus*) in beans may be killed by 48 hours' exposure to a dosage of 10 g chloropicrin per cubic meter, without altering the germinating power of the seeds.

——— and STAEHELIN, M. (138)
L'UTILISATION DES GAZ TOXIQUES DANS LA LUTTE CONTRE LES INSECTES NUISIBLES. Ann. Agr. Suisse 24: 9–18. 1923.

Chloropicrin at a concentration of 10 cc per cubic meter killed all adult *Oxythyrea hirta* Poda exposed to it in a bell jar for 2 hours. For this purpose chloropicrin was superior to carbon disulphide or hydrocyanic acid, although its action is not so quick as that of hydrocyanic acid. All larvae of *Pieris brassicae* were killed by chloropicrin at a concentration of 10 cc per cubic meter after exposure for 2 hours. The same concentration of chloropicrin killed grasshoppers under a bell jar in 2 hours also. Chloropicrin at the rate of 30 cc per cubic meter killed all *Microgaster glomeratus* after exposure for 6 hours. A viper under a bell jar resisted the action of chloropicrin at the rate of 30 cc per cubic meter for 7 minutes, then died. The authors conclude that in general the duration of exposure to a toxic vapor is more important than the concentration in causing the death of insects.

——— and STAEHELIN, M. (139)
LA DESTRUCTION DU VER BLANC OU LARVE DU HANNETON (*Melolontha vulgaris*). Ann. Agr. Suisse 24: 101–105. 1923.

Carbon disulphide, hydrocyanic acid, and chloropicrin were tested on *Melolontha*. Chloropicrin at a concentration of 10 g per cubic meter killed all larvae which were exposed to it for 4 hours. Chloropicrin and hydrocyanic acid act very much more quickly and completely than carbon disulphide.

——— and TONDUZ, P. (140)
STATION FEDERALE D' ESSAIS VITICOLES À LAUSANNE ET DOMAINE DE PULLY. Rap. ann., 1923. Ann. Agr. Suisse v. 25, no. 4. 1924.

Chloropicrin and hydrocyanic acid have a more rapid and complete action on the larvae of the hanneton (*Melolontha vulgaris*) than carbon disulphide (p. 389).

FARROW, E. S. (141)
GAS WARFARE. 253 p. New York. 1920.

At Edgewood Arsenal the final process of making chloropicrin was to mix a cream of bleaching powder with a solution of calcium picrate in large stills holding 5,000 gallons or more, and steam distil. Of the 424,771 75-mm shells filled with chloropicrin, 300,000 were shipped overseas. Chloropicrin is classified as a moderately volatile liquid of moderate persistency. It is a lung irritant, slightly less toxic than phosgene, and a tear producer. Chloropicrin produces a permanent casualty. In the open it persists for about 3 hours and in woods for about 12 hours. The clothes of men who have been exposed to chloropicrin are dangerous because of the gas which is carried on them. A mixture of 75 percent chloropicrin and 25 percent phosgene was used by the Americans and British, the shells being marked " PG." A mixture of diphosgene and chloropicrin was used in the German green cross 1 shell. The tactical use of different gases in warfare is described in detail.

FEYTAUD, J. (142)
SUR LA DESTRUCTION DES TERMITES PAR LA CHLOROPICRIN. Compt. Rend. Acad. Sci. [Paris]. 171: 440–442. 1920.

Tests with termites (*Reticulitermes* [*Leucotermes*] *lucifugus* Rossi) in bell jars showed that at 20° C. 2 mg per liter of chloropicrin sufficed to kill the insects in 12 hours and 5 mg per liter in 6 hours. All termites were killed, both those free and those in the interior of fragments of wood 10 cm thick. Termites in a house were killed by spraying with chloropicrin at the rate of 15 g per cubic meter and exposing for 16 hours.

FEYTAUD, J.—Continued. (143)

LES PARASITES DE LA VIGNE. INSECTES DES SOUCHES ET DES SARMENTS. Bul. Soc. Etude et Vulg. Zool. Agr. 20: 11. 1921.

The insects in galleries may be destroyed by plugging the orifice with a wad impregnated with carbon disulphide, benzine, or chloropicrin.

——— (144)

SUR LA PROTECTION DES EDIFICES CONTRE LES TERMITES. Bul. Soc. Etude et Vulg. Zool. Agr. 20: 17–23. 1921.

Under large bell jars at 20° C. 2 mg chloropicrin per liter kills termites at the end of 12 hours and 6 mg at the end of 6 hours.

——— (145)

DESTRUCTION DES VRILLETES. Bul. Soc. Étude et Vulg. Zool. Agr. 20: 124–125. 1921.

Chloropicrin has given good results against *Anobium hirtum* in department archives. It is very much less dangerous than carbon disulphide.

——— (146)

COMMUNICATIONS. Rev. Zool Agr. et Appl. 20 (3–4): 27–28. 1921.

At a meeting of the Société d'Étude et de Vulgarisation de la Zoologie Agricole on November 4, 1920, Dr. J. Feytaud described fumigation tests of Bertrand, and his own tests with chloropicrin for the control of termites.

——— (147)

LA CITE DES TERMITES. 134 p. Paris. 1921.

All termites in bell jars are killed at 20° C. by an exposure to a concentration of 2 mg chloropicrin per liter in 12 hours, or by 6 mg per liter in 6 hours. Fumigation of a badly infested house at the rate of 15 g per cubic meter, the rooms being kept closed for 16 hours, was successful. Termites within the beams were killed (p. 109–113).

——— (148)

STATION ENTOMOLOGIQUE DE BORDEAUX. Report of the Director. Ann. Epiphyties 8: 323. 1922.

Chloropicrin may be used advantageously in place of carbon disulphide for the fumigation of documents infested with *Anobium hirtum.*

——— (149)

LA DEFENSE DU BLE CONTRE LES PARASITES. Rev. Zool. Agr. et Appl. 22: 325–332. 1923.

The work of Moore, Bertrand, and Piutti with chloropicrin as a grain fumigant is briefly reviewed (p. 331).

——— (150)

ETUDE SUR LE DORYPHORA (LEPTINOTARSA DECEMLINEATA SAY) ET LES MOYENS DE LE DETRUIRE. Ann. Epiphyties 9: 209–306. 1923.

Tests with chloropicrin for the control of the Colorado potato beetle are described (p. 297–305). It is concluded that chloropicrin may be utilized as a subterranean insecticide against this insect. Its use at the rate of 750 to 1,000 liters per hectare assures the death of most of the insects. However, at an equal dose either by volume or by weight it appears less efficacious than carbon disulphide.

——— (151)

LES TRAITEMENTS D'EXTINCTION CONTRE LE DORYPHORA. Compt. Rend. Acad. Agr. France 9: 292–295. 1923.

Lime is not efficacious, and benzene, which must be used at the rate of 5 liters per square meter, is too expensive. Acetylene, chloropicrin, and carbon disulphide give good results. Measures against *Leptinotarsa decemlineata* Say. in France are discussed.

——— (152)

SUR LE MATÉRIAL A EMPLOYER CONTRE LE DORYPHORA. Compt. Rend. Acad. Agr. France 9: 361–363. 1923.

Carbon disulphide and chloropicrin give good results when injected into the soil, but the vapors of chloropicrin annoy animals as well as man.

Feytaud, J.—Continued. (153)
LES INSECTES DE L'ARACHIDE. Rev. Zool. Agr. et Appl. 23 (4) : 85–92. 1924.

Disinfection with chloropicrin is suggested (p. 91).

——— (154)
SUR L'EMPLOI DE LA CHLOROPICRINE CONTRE LES VRILLETTES. Rev. Zool. Agr. et. Appl. 23 : 243–244. 1924.

Anobium hirtum was killed by fumigation with chloropicrin at the rate of 15 g to a ¾-cubic meter box, the exposure being 24 hours. The documents in which the insects were found were not injured.

——— (155)
LA DESTRUCTION DES TERMITES DANS LES MURS. Rev. Zool. Agr. et. Appl. 24 : 47–50. 1925.

Termites in a wall were killed by the application of chloropicrin to the cavities.

——— (156)
LA DÉFENSE CONTRE LA BRUCHE DES HARICOTS. (ACANTHOSCELIDES OBTECTUS SAY) Rev. Zool. Agr. et Appl. 25 (12) : 177–188. 1926.

The work of Moore, Bertrand, Piutti, and Piedallu with chloropicrin is briefly reviewed. A dosage of 20 g chloropicrin per cubic meter and an exposure of 48 hours at a minimum temperature of 15° to 20° C. is recommended for destroying this insect.

——— (157)
LA CHLOROPICRINE CONTRE LA FAUSSE TEIGNE DES RUCHES. Rev. Zool. Agr. et Appl. 27 : 67. 1928.

The work of Jaubert in which he used chloropicrin in the destruction of the larvae of the false moth (*Galleria mellonella*) in bee hives and especially movable combs is discussed.

Fieldner, A. C., Teague, M. C., and Yore, J. H. (158)
PROTECTION AFFORDED BY ARMY GAS MASKS AGAINST VARIOUS INDUSTRIAL GASES. Chem. Warfare 5 (5) : 8–12. 1920.

The life in minutes of the standard filling against chloropicrin in various concentrations is shown in tabular form. The standard filling refers to 42 cubic inches of the 60 to 40 mixture of charcoal and soda lime. The action of many other gases against this and other fillings is also shown. The standard filling is recommended for use against chloropicrin.

Filippini, A. (159)
LA DIFESA CONTRO I GAS ASFISSIANTI. Ann. Ig. [Rome] 26 : 705–713. 1916.

A list of war gases is given. Chloropicrin is mentioned as a lachrymatory gas (p. 708). Gas masks are described.

Florentin, D. (160)
LA GUERRE DES GAZ. L'ALLEMAGNE ET LA GUERRE DES GAZ. Rev. Gen. Sci. 31 : 237–250. 1920.

The toxic dose of chloropicrin for a dog is 0.5 g. It is difficultly hydrolyzed, rather persistent, and without action on steel. Between July 1916 and November 1918 the Germans made 6,130 tons (1 ton=2,200 pounds) of chloropicrin. The Germans used phosgene mixed with diphosgene or chloropicrin in 18-cm smooth projectiles, marked D, each of which contained 7.3 kgs of toxic material. A 50-50 mixture of chloropicrin and surpalite was used in the German ordinary green cross shell, and a mixture of phosgene or diphosgene with chloropicrin in the double cross green shell. Details are given of caliber, weight of toxic material per shell, etc. (p. 240, 243, 247, 249).

Flury, F. (161)
ÜBER KAMPFGASVERGIFTUNGEN. I. ÜBER REIZGASE. Ztschr. Gesam. Expt. Med. 13 : 1–15. 1921.

The following constants for chloropicrin are given (p. 3) : Density, 1.69; boiling point, 113; volatility, 175,000 mm^3 per cubic meter; stable with water.

FLURY, F.—Continued. (162)
ÜBER KAMPFGASVERGIFTUNGEN. IX. LOKAL REIZENDE ARSENVERBINDUNGEN. Ztschr. Gesam. Expt. Med. 13: 523–578. 1921.

Man's toleration limit for chloropicrin is 60 mm^3 per cubic meter of air (p. 567).

——— and ZERNIK, F. (163)
SCHÄDLICHE GASE. 637 p. Berlin. 1931.

The chemical and toxicological properties of various gases, including chloropicrin, are fully described. Chloropicrin is referred to on pages 418, 516, 517, 518, 520, 540, 551, 613, and 614.

FORCRAND DE. (164)
RECHERCHES SUR LES HYDRATES SULFHYDRÉS. Ann. Chim. et Phys. (5) 28: 5–67. 1883.

A compound of the formula $CCl_3NO_2+2H_2S+23H_2O$ was formed (p. 23).

FRAHM, E. D. G. (165)
THE PREPARATION OF CHLOROPICRIN. Rec. Trav. Chim. Pays-Bas 50: 1125–1126. 1931. [Abstract in Chem. Abs. 26: 1236. 1932.]

Chloropicrin is usually prepared by the interaction of picric acid and bleaching powder. A different process, however, is described by Orton and Pope (*335*), and Orton and McKie (*334*). This method consists in the interaction of chlorine and picric acid with the addition of carbonates or borates in order to neutralize the hydrochloric acid formed in the reaction: $C_6H_2(NO_2)_3OH+11Cl_2+5H_2O \rightarrow 13HCl+3CO_2+3CCl_3NO_2$. The use of sodium hydroxide or soda was recommended especially but has the drawback that sodium picrate is only slightly soluble in soda solutions. On replacing the sodium hydroxide or soda by calcium hydroxide, which is suspended in the solution, chloropicrin was obtained in theoretical yield when the reaction was carried out at 0°.

FRANKLAND, P. F., CHALLENGER, F., and NICHOLLS, N. A. (166)
THE PREPARATION OF MONOMETHYLAMINE FROM CHLOROPICRIN. Jour. Chem. Soc. [London] 115: 159–162. 1919.

With iron filings and hydrochloric acid chloropicrin is reduced to methylamine hydrochloride and ammonium chloride. The quantity depends on the conditions of the experiment. Reduction with boiling alkaline ferrous hydroxide gave a product containing about 20 percent of ammonium chloride.

FRIES, A. A. (167)
GAS IN ATTACK. Chem. Warfare 2 (6): 2–8. 1919.

Chloropicrin was used in the World War in artillery shells, trench mortar bombs, and projectors. Mixtures of 30 percent chloropicrin by weight with 70 percent chlorine were used by the British in cylinders. Mixtures of 65 percent chloropicrin with 35 percent hydrogen sulphide were also used by the British in cylinders. Mixtures of 80 percent chloropicrin with 20 percent stannic chloride were used by the British, French, and Americans in artillery shells, trench mortar bombs, and projectors. Mixtures of 75 percent chloropicrin with 25 percent phosgene were used by the British.

——— (168)
GAS IN ATTACK. Natl. Serv. with Internatl. Mil. Digest 5: 327–336. 1919.

Chloropicrin is classified with the gases that are highly lethal but have low persistency (phosgene, cyanogen chloride, chlorine, and diphosgene), although chloropicrin is more persistent than any of the others. Chloropicrin was often used in Livens projectors, although it was not nearly so effective as phosgene (p. 330–335).

——— (169)
CHEMICAL WARFARE AND ITS RELATIONS TO ART AND INDUSTRY. Chem. Warfare 7 (4): 2–8. 1921.

Chloropicrin and cyanogen chloride are useful in killing weevils in oats and other grain. Reference is made to experiments by the Italians and French with chloropicrin against insects in grain and cereals. The author believes that some of the tests in the United States with this gas have used too high concentrations, which have proved injurious to the plants or

FRIES, A. A.—Continued.

CHEMICAL WARFARE AND ITS RELATIONS TO ART AND INDUSTRY—continued. cereals. The advantage of chloropicrin over hydrocyanic acid is its lower toxicity to man in the gas concentration used. Chloropicrin is more toxic than carbon disulphide and carbon tetrachloride; also it is nonflammable. (p. 4, 6–7).

——— and WEST, C. J. (170)

CHEMICAL WARFARE. 445 p. New York. 1921.

The Germans used large quantities of superpalite (trichloromethylchloroformate or diphosgene), alone and mixed with chloropicrin, in shells of every caliber up to and including the 15-cm howitzer. It has been stated that a mixture of chloropicrin (25 percent) and chlorine (75 percent) has been used in cloud attacks. Chloropicrin was used mainly because of its peculiar property of causing vomiting when inhaled, and also because at first it was particularly difficult to prepare a charcoal which would absorb it. The comparative value of the various lachrymators is shown in the following:

	Mg per liter of air necessary to produce lachrymation
Bromobenzyl cyanide	0. 0003
Martonite	. 0012
Ethyl iodoacetate	. 0014
Bromoacetone	. 0015
Xylyl bromide	. 0018
Benzyl bromide	. 0040
Bromoketone	. 0110
Chloroacetone	. 0180
Chloropicrin	. 0190

The manufacture of chloropicrin from bleaching powder and calcium picrate at Edgewood Arsenal is described. Concentrations between 2 and 25 parts per million produce an overpowering impulse to close the eye within 3 to 30 seconds after exposure. Chloropicrin is absorbed by the activated charcoal used in the American gas mask, and is absorbed equally well at all temperatures. On the other hand, moisture has a very decided effect. Chloropicrin is used only in shells. German shells usually contained a mixture of superpalite (diphosgene) and chloropicrin, the relative proportions being about 75 to 25. These were called green cross shells because of the peculiar marking on the outside. Mixtures of phosgene and chloropicrin (50–50) have also been used. The so-called " NC mixture of the Allies " consisted of 80 percent of chloropicrin and 20 percent of stannic chloride. It was used in Livens projectors and in hand grenades. Later, owing to the shortage of tin, the stannic chloride was replaced by a mixture of silicon and titanium chlorides. While chloropicrin is sufficiently volatile to keep the strata of air above it thoroughly poisonous, it is still persistent enough to be dangerous after 5 or 6 hours.

FRYER, J. C. F. (171)

REPORT ON THE OCCURRENCE OF INSECT PESTS ON CROPS IN ENGLAND AND WALES FOR THE YEARS 1920–1921. Gt. Brit. Min. Agr. and Fisheries Misc. Pub. 39, 40 p. London. 1923.

Chloropicrin as a surface dressing proved useless against the cutworm (*Agrotis* [*Euxoa*] *segetum*). Although its effects were greater when injected into the soil, the treatment was not practicable on a field scale (p. 6).

G., G. H. (172)

CHLOROPICRIN AS A SOIL FUMIGANT. Pineapple News 2: 202–203. 1928.

Heterodera larvae remained alive for several minutes in water to which had been added a drop of chloropicrin, even though they were almost in contact with the drop. When, however, chloropicrin was mixed with water by first dissolving it in alcohol and then diluting with water, the toxic effect on nematodes was immediate. One part of chloropicrin to 1,000 parts of the alcohol-water mixture killed the nematode larvae immediately. One to 2,000 did not.

A recent newspaper article states that field tests made with chloropicrin by Maxwell Johnson of the California Packing Corp. have given promising indications. Reference is made to work by Strand (*459*).

GALLER O., and SASSIQUINE, T. (173)
EXPERIMENTS ON THE APPLICATION OF CHLOROPICRIN FOR DISINFECTION PURPOSES AND THE DISINFECTION OF DWELLINGS AND CLOTHES DURING THE OUTBURST OF BLACK PLAGUE. Rev. Microbiol. Épidém. 6: 275–279. 1927. [Abstract in Chem. Abs. 22: 4693. 1928.]

After 48 hours' exposure to chloropicrin, injected at the rate of 5 to 10 cc per cubic meter, all the bacterial cultures and insects in a house are killed.

GARDNER, J. A., and FOX, F. W. (174)
CHLOROPICRIN. PART I. Jour. Chem. Soc. [London] 115: 1188–1194. 1919.

At its boiling point chloropicrin slowly decomposes into carbonyl chloride and nitrosyl chloride, according to the reaction $CCl_3NO_2=COCl_2+NOCl$: 200 cc of chloropicrin held at the boiling point decomposed at the rate of 2 cc per day.

——— and WILLIAMS, M. (175)
IMPROVEMENTS IN AND RELATING TO THE PREPARATION OF QUINOLINE AND QUINOLINE DERIVATIVES OR COMPOUNDS. British Patent 198,462, issued June 28, 1923; applied for March 13, 1922.

The authors employ chloropicrin as a nitro oxidizing agent in place of nitrobenzene in the synthesis of quinoline and quinoline derivatives by the Skraup reaction or the Döbner and Von Miller reaction.

GAUDOT, G. (176)
LES SAUTERELLES EN CAMARGUE. Jour. Agr. Prat. 35: 300. 1921.

Chloropicrin is mentioned as one of the insecticides to be used against grasshoppers.

GAUMONT, L. (177)
CONTRIBUTION A L'ETUDE DES APHIDIDAE DE FRANCE. Ann. Epiphyties 9 (5): 309–346. 1923.

The author has used with complete success the following mixture against the Puceron lanigere du Pommier [woolly apple aphid]: I. soap râpé, 5 g; chloropicrin, 5 g; water, 1,000 g. These are emulsified in the usual way. II. Boiling alcohol, 150 g; lacquer gum, 20 g. III. Sodium hydroxide solution 36° Baumé. These three products are mixed at the time of using in the following proportions: 800 g of I; 180 g of II; and 20 g of III (p. 321).

——— (178)
LES PUCERONS DES PLANTES POTAGÈRES. Cong. Natl. pour la Lutte Contre les Ennemis des Cultures, Lyon, 1926. Compt. Rend. Seances, p. 131–136. Paris. 1927.

For the destruction of subterranean pests (Trama, Pemphigus, Alphis), fumigation with blocks of peat each impregnated with 10 cc of chloropicrin and placed in the ground at the rate of 6 per cubic meter is recommended.

——— (179)
LA LUTTE CONTRE LES RAVAGEURS SOUTERRAINS DES PLANTES MARAICHERES. Cong. Natl. pour la Lutte Contre les Ennemis des Cultures, Lyon, 1926. Compt. Rend. Seances, p. 137–140, illus. Paris. 1927.

To combat subterranean pests blocks of peat measuring 5 by 3 by 2 cm^3 were impregnated with 10 cc of chloropicrin each and placed in the ground 0.33 meter apart. The chloropicrin was purchased at a cost of 5 francs per kilogram.

GEBISCH, R. (180)
VERFAHREN ZUR VERNICHTUNG VON UNGEZIEFER DURCH BEGASUNG. Austrian Patent 124,486, issued September 10, 1931; applied for June 20, 1930.

Bedbugs, roaches, rats, mice, and other pests are destroyed by a mixture of carbon tetrachloride and chloropicrin in ratios ranging from 3:1 to 1:3. This mixture may be applied as a spray or as a fumigant.

GEISSE, L. (181)
UEBER CHLOROPIKRIN. Ann. Chem. 109: 282–286. 1859.

With iron filings and acetic acid chloropicrin is reduced to monomethylamine; also with ferrous sulphate and potassium hydroxide. No ammonia is formed.

GÉNIEYS, P. (182)
UN ENNEMI DES ROSIERS. Ann. Epiphyties 13: 48–78. 1927.

An experiment with chloropicrin as the insecticidal fumigant against *Coraebus rubi* L. on a potted plant was fatal to the plant, but the experiment should be repeated under natural conditions of culture to be convincing.

GERHARDT, C. (183)
CHLOROPICRINE. Compt. Rend. Trav. Chim. 5: 34–35. 1849.

Gerhardt suggests the formula CCl_3NO_2 for chloropicrin instead of $C_4Cl_{14}N_4O_{10}$, as proposed by Stenhouse. Chloropicrin thus appears to be nitrated chloroform.

GERTOPAN, A. (184)
DIE VERWENDUNG DES CHLORPIKRINS ZUR BEKÄMPFUNG DER GETREIDESCHÄDLINGE UND ALS DESINFEKTIONSMITTEL. Osteurop. Landw. Ztg., nr. 3 (8), 7–8. 1925. [In Russian. Abstract in Zool. Ber. 7 (9/11): 315. 1925.]

The use of chloropicrin against cereal insects is discussed. Reference is made to work in France and Germany which indicates that a dosage of 20 cc chloropicrin per cubic meter should be used at a temperature of from 15 to 20° C.

GHESQUIERE, J. (185)
LE "VER ROSE" AU CONGO BELGE, SA REPARTITION GEOGRAPHIQUE ET SON IMPORTANCE ECONOMIQUE EN AFRIQUE. Bul. Agr. Congo Belge 14 (1): 178–188. 1923.

Reference is made to the work of Vayssiere (*501*) on destroying the pink boll worm in cotton by fumigation with chloropicrin.

GILCHRIST, H. L. (186)
CHEMICAL WARFARE. MEDICAL ASPECTS. War Dept. [U.S.], Chem. Warfare Med. Div. 28 p. Washington, D.C., 1922.

The medical treatment of war gas poisoning, including chloropicrin, is discussed.

——— (187)
REPORTS ON THE AFTER EFFECTS OF WARFARE GASES. War Dept. [U.S.], Chem. Warfare Med. Div. 112 p. Washington, D.C., 1922.

Chloropicrin is listed as one of the lung irritants (p. 9).

——— (188)
CHEMICAL WARFARE AND ITS RELATION TO THE MEDICAL DEPARTMENT. Mil. Surg. 53: 144–154. 1923.

Chloropicrin is listed as one of the war gases. An outline of the medical treatment for different types of war gas poisoning is given, and the organization of the medical department is described.

——— (189)
A COMPENDIUM ON CHEMICAL WARFARE AND ITS RELATION TO THE MEDICAL DEPARTMENT. War Dept. [U.S.], Chem. Warfare Med. Div. 12 p. Washington, D.C., 1924.

Chloropicrin is listed as a lung irritant.

GILDEMEISTER, M., and HEUBNER, W. (190)
ÜBER KAMPFGASVERGIFTUNGEN. VI. DIE CHLORPIKRINVERGIFTUNG. Ztschr. Gesam. Expt. Med. 13: 291–366. 1921.

Chloropicrin slowly oxidizes potassium iodide to iodine and hemoglobin to methemoglobin. Locally it is extremely irritating. After injection it first stimulates, then depresses the central nervous system, and produces pulmonary edema and multiple capillary hemorrhages. Inhalation of large doses leads to passive hyperemia in the lungs, in severe cases to failure of the ventricle, and in less severe cases to a functional disturbance manifested by dilatation and slowing of the pulse and to parenchymatous degeneration of the liver, kidneys, and myocardium. Inhalation of small doses causes an inflammatory edema of the lungs almost identical with that produced by phosgene and a transitory diminution in general katabolism.

GILLILAND, W. L. (191)
THE USE OF GAS IN THE NEXT WAR. Chem. Warfare 13 (3): 55–56. 1927.

In illustrating the point that the chemical industry is the most quickly mobilized of all the industries and that it reaches its maximum capacity in the shortest time, attention is called to the fact that American chemists were able in a few months to devise a plan for the manufacture of chloropicrin on a large scale. The plant erected at Edgewood Arsenal had a capacity of 100,000 pounds a day (p. 56).

GILMAN, E. D. (192)
PHYSICS AND PHYSIOLOGY OF WAR GASES. Chem. Warfare 8 (6): 11–20. 1922.

Diphenylchlorarsine is used alone or mixed with diphosgene or chloropicrin. Chloropicrin is described as a colorless liquid when pure, which turns yellowish-brown on standing. Its vapor is 5.7 times as heavy as air. It is a lachrymator and a lung irritant. In addition to causing edema and cyanosis, it affects the kidneys, producing Bright's disease, albumen in the urine, etc. It is persistent.

GILMAN, H., and FOTHERGILL, R. E. (193)
LA STRUCTURE ET LA TAUTOMÉRIE DE L'ORTHO-NITRO-BENZALDÉHYDE. L'INTERVENTION DES GROUPEMENTS NITRÉS DANS LA MÉTHODE DE ZÈRÈWITINOFF POUR LE DOSAGE QUANTITATIF DE L'HYDROGÈNE ACTIF. Bul. Soc. Chim. France 45: 1132–1136. 1929.

Nitro compounds interfere with the method of Zèrèwitinoff. Methyl magnesium iodide prepared in iso amyl ether was heated with chloropicrin, and a volume of gas equivalent to 0.51 percent active hydrogen was evolved, whereas there is no hydrogen in chloropicrin.

GORYAINOV, A. A. (194)
CHLOROPICRIN IN THE CONTROL OF GRAIN AND PLANT PESTS. Defense des Plantes 3: 258–271. 1926. [In Russian. Abstract in Rev. Appl. Ent. (A) 14: 610. 1926.]

Chloropicrin destroys wheat nematodes in galls in a concentration of either 20 or 40 c.c. per cubic meter. The work of French authors is reviewed. Chloropicrin is considered to be the best fumigant for controlling pests of stored products, but must not be used when fermentation is in progress, as this is inhibited by the action of the gas.

GOTTS, R. A., and HUNTER, L. (195)
PREPARATION AND REACTIONS OF THE DIHALOGENODINITROMETHANES. Jour. Chem. Soc. [London] 125: 442–450. 1924.

When 2-4-dichloroacetanilide is warmed with concentrated nitric acid dichlorodinitromethane is formed, together with chloropicrin and other byproducts.

GREEN, A. G., and ROWE, F. M. (196)
THE CONVERSION OF ORTHONITROAMINES INTO ISOOXADIAZOLE OXIDES (FUROXANS). Jour. Chem. Soc. [London] 103: 2023–2029. 1913.

Oxidation of the following with sodium hypochlorite causes disruption of the ring and formation of chloropicrin: Dinitroaniline, nitro-p-phenylenediamine, nitro-acetyl-p-phenylenediamine, and the azo compound obtained by combining diazotised nitro-p-phenylenediamine with beta-naphthol (p. 2024).

——— and ROWE, F. M. (197)
THE CONVERSION OF O-NITROAMINES INTO ISOOXADIAZOLE OXIDES, AND OF O-NITROSOAMINES INTO ISOOXADIAZOLES. Jour. Chem. Soc. [London] 111: 612–620. 1917.

Hypochlorite oxidation of 2:4 dinitronaphthlyamine, either in suspension or in alcoholic solution, at the ordinary temperature or when cooled in ice, resulted in disruption of the ring, accompanied by a strong odor of chloropicrin (p. 613).

GUERIN, P., and LORMAND, C. (198)

ACTION DU CHLORE ET DE DIVERSES VAPEURS SUR LES VEGETAUX. Compt. Rend. Acad. Sci. [Paris] 170: 401–403. 1920.

Most plants kept for an hour in an atmosphere of 1 to 2,000 of chlorine, palite, bromoacetone, chloropicrin, or yperite (mustard gas) resist the action of these compounds. The plants lose their leaves, but new ones appear. The leaves die in consequence of plasmolysis.

——— and LORMAND, C. (199)

ACTION PLASMOLYSANTE D'UN CERTAIN NOMBRE DE VAPEURS. Compt. Rend. Acad. Sci. [Paris] 170: 1598–1601. 1920.

Chloropicrin causes plasmolysis in leaves.

GUILLEMARD and LABAT. (200)

CARACTERISATION DE LA CHLOROPICRINE. Bul. Soc. Pharm. Bordeaux, 1919, no. 2. [Abstract in Ann. Chim. Analyt. (2) 2: 120–121. 1920.]

Alkali polysulphide solution destroys the odor of chloropicrin. A yellow color is obtained when a drop of chloropicrin is boiled with alcoholic potassium hydroxide and a small quantity of thymol. The substitution of resorcinol for thymol produces a red color. The addition of sulphuric acid to the thymol mixture produces a reddish violet color, and the whole mixture on dilution with acetic acid exhibits an absorption band in the green portion of the spectrum. A mixture of chloroform and a trace of sodium nitrite gives the same reactions. Both chloroform and chloropicrin yield a carbylamine. Chloropicrin when boiled with potassium hydroxide solution gives, after cooling, reactions characteristic of nitrous acid.

GUYTON, T. L. (201)

MEASURING THE TOXICITY OF INSECT FUMIGANTS. Crop Protect. Inst. Circ. 9 (3): 1. 1930.

This is an abstract of the article by Strand (*461*).

HAASE, F. (202)

EINIGE SCHMELZPUNKTSBESTIMMUNGEN. Ber. Deut. Chem. Gesell. 26: 1052–1054. 1893.

The melting point of chloropicrin is —64.0° C.

HAGAN, H. R. (203)

VACUUM FUMIGATION OF PINEAPPLE PLANTING MATERIAL. Jour. Econ. Ent. 24: 1002–1012. 1931.

Among the principal Arthropoda infesting pineapple planting material are the pineapple mealybug (*Pseudococcus brevipes* Ckll.), thrips (*Thrips tabaci* Lind.), the pineapple scale (*Diaspis bromeliae* Kerner), the common red spider (*Stigmaeus floridanus* Banks), and the pineapple mite (*Tarsonemus ananas* Tyron). Planting material proved to be quite intolerant to carbon bisulphide, considerably more resistant to chloropicrin, and withstood without injury heavy charges of hydrocyanic acid gas. The last also gave satisfactory control of the parasites within the tolerance limits of the host.

Fumigation tests were made in a fumigator containing 56 cubic feet of space at a temperature of about 90° F. Previous experience has shown that atmospheric fumigation with chloropicrin gives fairly satisfactory control. Large numbers of eggs seem to be unaffected by ordinary dosages of this gas. Moreover, the percentage of insects that recover a few days after the fumigation is surprisingly high. In tests in the vacuum fumigator dosages of chloropicrin ranged from 4½ to 54½ fluid ounces per 1,000 cubic feet of space. In some tests about 10 percent of carbon dioxide was added. The usual fumigation cycle was as follows: Vacuum, 28 inches; chloropicrin plus air to vacuum, 25 inches; then carbon bisulphide plus air to atmospheric pressure; fumigation period, 1 hour; vacuum, 28 inches; air.

Eggs of thrips were unaffected by chloropicrin at dosages of 36 fluid ounces per 1,000 cubic feet. This dosage killed the red mites but not their eggs. The planting material showed burning in almost every one of the slips, suckers, and crowns. Very severe injury results from the storage of fumigated planting material. This can be minimized only by prompt aeration.

HAMER, F. E. (204)

"CHEMICAL AGE" LETTERS FROM AMERICA. VI. CHEMICAL WARFARE SERVICE—A CHAT WITH GENERAL FRIES—A VISIT TO EDGEWOOD ARSENAL. Chem. Age [London] 7: 853–855. 1922.

"Other gases, such as chloropicrin and cyanogen chloride, are useful in killing weevil in oats and other grains."

HANSLIAN, R. (205)

DAS CHEMISCHE KAMPFMITTEL IM WELTKRIEGE. Ber. Deut. Pharm. Gesell. 31: 219–233. 1921.

Hanslian states that 2,400 mg of chloropicrin per cubic meter of air will kill a man, if breathed for 1 minute (p. 222).

HANTZSCH, A. (206)

DIE KONSTITUTION DER CARBONIUMSALZE. Ber. Deut. Chem. Gesell. 54: 2573–2612. 1921.

In solution in chloropicrin triphenylmethylhaloids are partly isomerised to triphenylcarboniumhaloids (p. 2590).

——— AND VOIGT, K. (207)

UBER KONJUGIERTE ACI NITRO KORPER. Ber. Deut. Chem. Gesell. 45: 85–117. 1912.

The optical absorption of chloropicrin is very similar to that of nitromethane (p. 106).

HARNED, H. S. (208)

THE VELOCITY OF ADSORPTION OF CHLOROPICRIN AND CARBON TETRACHLORIDE BY CHARCOAL. Jour. Amer. Chem. Soc. 42: 372–391. 1920.

Detailed results are given for French canister charcoal of 14 to 16 mesh, and the same after various treatments. The capacity per gram of charcoal was 0.2800 g at a pressure of approximately 5×10^3 bars and 0.3100 g at 5×10^4 bars, an increase of only 10 percent in capacity, with a tenfold increase in pressure (p. 374–378).

HARPER, E. M., AND MACBETH, A. K. (209)

COLORATIONS PRODUCED BY SOME ORGANIC NITRO-COMPOUNDS WITH SPECIAL REFERENCES TO TETRANITROMETHANE. Jour. Chem. Soc. [London] 107: 87–96. 1915.

Chloropicrin does not develop a band in its absorption spectrum when influencing substances (in general, compounds that can exercise a higher degree of valency) are added to it, as does tetranitromethane under similar circumstances.

HARTEL, H. v. (210)

ÜBER EXISTENZ UND DARSTELLUNG DES ORTHOKOHLENSÄURE-TETRAMETHYLESTERS. Ber. Deut. Chem. Gesell. 60: 1841. 1927.

Chloropicrin and sodium methylate react vigorously to form orthocarbonic tetramethyl ester.

HARTLEY, H. (211)

CHEMICAL WARFARE. Brit. Assoc. Advancement Sci., Rpt. Meeting 87: 393–402. 1919.

In April 1917, during the Arras battle, a variant of the green cross filling appeared containing 50 percent of chloropicrin, a lachrymator with asphyxiant properties against which the PH helmet offered no protection, but as our troops were already equipped with a box respirator the new filling had no advantage over the old (p. 394).

HASSELMANN, C. M. (212)

NEUERE REIZSTOFFZUSÄTZE ZUR BLAUSÄURE BEI ENTWESUNGEN. Zentbl. Gewerbehyg. u. Unfallverhütung (n. F. 4) 14 (3): 65–69. 1927.

Chloropicrin is included in a list of warning agents used in combination with hydrocyanic acid. The bearable limit of chloropicrin in the atmosphere is 60 mg per cubic meter, whereas 19 mg per cubic meter irritates the eyes.

HASSON, J. (213)
BEKÄMPFUNG TIERISCHER SCHÄDLINGE DURCH VERGASUNG DES BODENS. Wiener Landw. Ztg. 70: 471. 1920.

In these experiments a field infested by larvae of Agriotes and other pests was fumigated with chloropicrin by means of a special apparatus. It comprises a container placed on the front of an ordinary plough and fitted with an air pump, worked by a rod connected with one of the wheels, and with pipes to a series of five nozzles, any one of which can be shut off. These nozzles spray the chloropicrin on the earth turned up in the preceding furrow, on the sods that are being turned over, and on all parts of the furrow. All pests are destroyed, but it is not known whether useful bacteria share the same fate. The apparatus uses about 1¾ pints of chloropicrin a minute.

HEERDT, W., and LINGLER, J. (214)
VERHINDERUNG VON UNGLÜCKSFÄLLEN DURCH EINATMEN VON LEUCHTGAS O. DGL. DURCH ZUSATZ VON REIZSTOFFEN DIE DIE ORGANE, INSBESONDERE DIE AUGEN UND ATMUNGSORGANE VON MENSCHEN UND TIEREN ANGREIFEN. German Patent 447,655, issued August 2, 1927; applied for August 1, 1926.

Chloropicrin may be used as an irritant to prevent accident by inhalation of illuminating gas or the like.

HELLER, H. (215)
ANGEWANDTE ZOOLOGIE. Naturw. Wchnschr. (n. F. 18.) 34: 425–426. 1919.

A review of the work of Bertrand (*50*) with chloropicrin as an insecticidal fumigant.

——— (216)
ZUR CHEMISCHEN SCHÄDLINGSBEKÄMPFUNG. Ztschr. Angew. Chem. Aufsatzteil 33: 157. 1920.

The work of Bertrand on chloropicrin is discussed. Heller suggests chloropicrin as a substitute for hydrocyanic acid.

HENDERSON, T., and MACBETH, A. K. (217)
THE LABILE NATURE OF THE HALOGEN ATOM IN ORGANIC COMPOUNDS. PART I. TITANIUM REDUCTIONS OF SUBSTITUTED NITROPARAFFINS. Jour. Chem. Soc. [London] 121: 892–903. 1922.

Hydrazine removes one of the chlorine atoms from chloropicrin very slowly in the cold. Potassium ferrocyanide is without action. Titanous chloride reduces the nitro group but leaves the halogen unattacked (p. 894).

HERBST, H. (218)
ÜBER DEN EINFLUSS DES WASSERGEHALTES AUF DIE ADSORPTIONSLEISTUNG EINER AKTIVEN KOHLE. Biochem. Ztschr. 118: 103–119. 1921.

Charcoal can take up to 50 percent of its weight in water and still appear to be dry. Such an adsorption of water is due to capillary forces and decreases to a marked degree the pure absorptive power of the charcoal for gases. This is shown in the tables for chloropicrin, phosgene, chlorine, and hydrocyanic acid. There is a catalytic adsorptive power in charcoal, which increases with the moisture content, being optimum at 22 to 30 percent.

——— (219)
DER EINFLUSS DES SALZGEHALTES AUF DIE ADSORPTIONSLEISTUNG EINER AKTIVEN KOHLE, SOWIG EINE ÜBERSICHT ÜBER DIE HAUPTEIGENSCHAFTEN DER WICHTIGSTEN TECHNISCH HERGESTELLTEN AKTIVEN KOHLEN. Kolloidchem. Beihefte 21: 1–36. 1925.

A study of the effect of salt solution and other factors on the adsorption by various charcoals of chlorine, chloropicrin, phosgene, and hydrocyanic acid gas.

——— (220)
ÜBER DIE FLÜCHTIGKEIT UND VERNEBELUNG EINER REIHE ORGANISCHER STOFFE. Kolloidchem. Beihefte 23: 313–344. 1926.

In tabular form are given the following data for a number of organic substances, including chloropicrin: The state of the material at room temperature, the melting point, the boiling point (calculated and observed), HERBST, H.—Continued.

ÜBER DIE FLÜCHTIGKEIT UND VERNEBELUNG EINER REIHE ORGANISCHER STOFFE—continued.

the volatility by the boiling-point method and by vapor-pressure measurements in the presence of inert gas, the stability with water, the concentration at which it can be borne, and the lethal concentration (the last not given for chloropicrin). Curves are plotted for the different substances showing the relation of volatility to the boiling point (p. 330–331, 342).

HERITAGE, A. M. (221)

REFRIGERATION REQUIREMENTS OF CHEMICAL WARFARE. Mech. Engin. [New York] 41: 806–810. 1919.

Refrigeration equipment at Edgewood, Md., is described. This plant had an estimated capacity on January 1, 1919, of 3,000,000 pounds of chloropicrin per month. From Stamford, Conn., 111,853 pounds of chloropicrin was shipped. The total shipped overseas was 3,806,000 pounds.

HERRICK, G. W. (222)

MANUAL OF INJURIOUS INSECTS. 489 p., illus. New York. 1925.

Refers to the work of Moore (*312*) and Moore and Hirschfelder (*317*) (p. 69–70).

HERTY, G. H. (223)

GAS OFFENSE IN THE UNITED STATES. A RECORD ACHIEVEMENT. Jour. Indus. and Engin. Chem. 11: 5–12. 1919.

Chloropicrin is a strong lethal gas and is also a strong lachrymator. It was employed in the war for filling projectiles of all types, either by itself or mixed with stannic chloride or phosgene. A large portion of the picric acid used at the Edgewood plant in making chloropicrin was that rejected by both the United States and allied governments on account of excessive lead content. An outline of the process of manufacture is given (p. 7, 10).

HEUBNER, W., and MEIER, R. (224)

ÜBER TYPISCHE GIFTWIRKUNGEN AM STOFFWECHSEL DER HEFE. Nachr. Gesell. Wiss. Göttingen. Math.-Phys. Kl. 1927: 115–124. 1927.

A study of cell poisons is made by means of measurement of changes in oxygen consumption and carbon dioxide evolution. The work on chloropicrin was done with distillery yeast and torula suspended in a solution of 1 percent potassium biphosphate and 3 percent glucose at 28°. The results are tabulated. No increase in the life activity as indicated by oxygen consumption could be attributed to traces of poisons (p. 119–124).

HILL, L. (225)

LECTURE ON THE PATHOLOGY OF WAR POISON GASES. Jour. Roy. Army Med. Corps 35: 334–343. 1920.

Chloropicrin dissolved in Ringer's solution and injected subcutaneously produced no toxic effect in animals (p. 336).

HOFMANN, A. W. (226)

ÜBER SYNTHESEN DES GUANIDINS. Ann. Chim. 139: 111. 1866.

Describes the preparation of chloropicrin from picric acid and chloride of lime. Chloropicrin combines with ammonia to form guanidin hydrochloride (CH_5N_3HCl). The boiling point of chloropicrin is given as 112° C.

——— (227)

ZUR KENNTNISS DES GUANIDINS. Ber. Deut. Chem. Gesell. 1: 145–147. 1868.

By heating chloropicrin with a strong alcoholic solution of ammonia in an autoclave at 100° C. for several hours guanidin is obtained.

HOWARD, L. O. (228)

REPORT OF THE ENTOMOLOGIST. U.S. Dept. Agr. Bur. Ent. Ann. Rpt. 1924. 30 p.

Chloropicrin in low dilution in mineral oil, which was first tested this year, is a very promising repellent dressing for use against screw worm (p. 23).

HOWORTH, F. W. (229)

NEW OR IMPROVED DISINFECTANT AND INSECTICIDE AND PROCESS OF PRODUCING THE SAME. British Patent 20,387 (1908), issued September 10, 1908; applied for September 12, 1907.

The Chemische Fabrikswerke G.m.b.H. of Austria, through Howorth, claims the process for producing a disinfectant and insecticide by intimately distributing one or more nitro-halogen compounds of the aliphatic or aromatic series, such as chloropicrin, in a soapy mass or soapy emulsion. Disinfectants of any kind usually employed, such as cresol, formalin, naphthalene, camphor or terpene, may be added. One of the examples given is: Chloropicrin, 0.1 part by weight, is added to 100 parts of a soapy mass and stirred until the mass is completely homogeneous.

HOYT, L. F. (230)

COMPARATIVE TESTS WITH CERTAIN FUMIGANTS. Indus. and Engin. Chem. 20: 835–837. 1928.

A dosage of 0.8 pound of chloropicrin per 1,000 cubic feet used at 75° to 80° F. for 24 hours in a Plymetl fumigating vault gave a 100 percent kill of the three species of insects used, larvae of the clothes moth, *Tineola bisselliella;* larvae of the Indian meal moth, *Plodia interpunctella;* and adult confused flour beetles, *Tribolium confusum.* The effect of the fumigant on food products was studied. Those products rich in fat absorbed it, requiring exposure to the air for varying lengths of time to return to a condition of palatability. The fumigant had no consistent effect on the germination of seeds (oats, wheat, white beans, shelled peanuts, and clover). There was apparently no corrosion or tarnishing of the various metals used.

——— and **ELLENBERGER, E. P.** (231)

SOME FUMIGATION TESTS WITH CHLOROPICRIN. Indus. and Engin. Chem. 19: 461–464. 1927.

Corn meal heavily infested with confused flour beetle (*Tribolium confusum* Duv.) in a 1-gallon container was treated for 48 hours at 21° C. with chloropicrin at the rate of 0.8 pound per 1,000 cubic feet. All adults and larvae were killed. Tests made on larvae of *Dermestes vulpinus* in dried tankage indicated that a concentration of 1.25 pounds of chloropicrin per 1,000 cubic feet was necessary to kill the insects in 48 hours. Tests on fumigating oats, corn, wheat, buckwheat, raw peanuts, cocoa, rolled oats, macaroni, rice, flour, wheat cereal, and cornstarch were made in a gas-tight compartment of 22.7 cubic feet. Chloropicrin was used at the rate of 0.8 pound per 1,000 cubic feet. The box was allowed to remain sealed for 48 hours, the temperature being 21°, then opened and aired for 3 to 4 hours. No abnormal odor or flavor was detected in these foods, either uncooked or cooked, within 24 hours after fumigation. The confused flour beetle, adults and larvae, and Indian meal moth (*Plodia interpunctella* Hbn), moths, larvae, and pupae, were all killed or died shortly after fumigation. Sunflower seed packed in burlap bags was fumigated in a room of 7,500 cubic feet capacity. The chloropicrin was sprayed in by air pressure at the rate of 0.8 pound per 1,000 cubic feet, and a contact of 1 week was allowed, the temperature being 20° to 25°. All adults and larvae of the Indian meal moth were killed, but a number of pupae survived and emerged the following spring. Flour, cocoa, lard, butter, macaroni, and rolled oats in the room were not damaged in any way. The germination of the sunflower seed, and also of corn, oats, buckwheat, and wheat, was not impaired. Another fumigation was made at the rate of 1.33 pounds per 1,000 cubic feet, and the room was kept closed for 6 days. This killed all Mediterranean flour moths, but a few confused flour beetles were not killed. Lard, nut margarine, dried fruits, nut meats, and nuts in the shell placed in the room were entirely normal in flavor. Another fumigation at the rate of 1.33 pounds per 1,000 cubic feet, with an exposure of 2 weeks, gave no better results. A bibliography of 39 titles is appended.

HUMPHRIES, S. (232)
PESTS IN WHEAT AND ITS PRODUCTS. Natl. Joint Indus. Council Flour-Milling Indus. Tech. Ed. Series Pamphlet 5, 36 p. London. 1930.

Brief mention is made of chloropicrin as a recent fumigating agent. It is stated to kill all the worst of the mill pests even at low temperatures (p. 16).

INGOLD, C. K., and POWELL, W. J. (233)
EXPERIMENTS ON THE SYNTHESIS OF THE POLYACETIC ACIDS OF METHANE. PART II. SOME ABNORMAL CONDENSATIONS OF MALONIC AND CYANOACETIC ESTERS WITH HALOGENATED METHANES. Jour. Chem. Soc. [London] 119: 1222–1231. 1921.

In condensing chloropicrin with ethyl sodiomalonate and with ethyl sodiocyanoacetate, it is necessary to add the chloropicrin very slowly on account of the large amount of heat developed. The products formed are ethyl ethanetetracarboxylate or ethyl $\alpha\alpha'$-dicyanosuccinate, according to the sodio-ester employed (p. 1231).

JAUBERT, G. F. (234)
DESTRUCTION DE LA FAUSSE TEIGNE (GALLERIA MELLONELLA) AU MOYEN DE LA CHLOROPICRIN. Compt. Rend. Acad. Sci. [Paris] 185: 1608–1610. 1927.

The great damage caused by the larvae of the false moth (*Galleria mellonella*) to bee hives and especially to the movable combs may be fought effectively with chloropicrin. This substance may be either pure or in carbon tetrachloride solution (1:9 by volume) spread out on strips of filter paper. In an atmosphere containing 20 to 30 mg of chloropicrin (pure or diluted with carbon tetrachloride) per liter, eggs, larvae, and moths of the false moth are killed in a very short time. For larvae and moths pure chloropicrin suffices, but for eggs, the carbon tetrachloride vapor seems to take part in the lethal action, perhaps as a solvent for fats preparing the way for the action of the chloropicrin. Five tenths of a gram of chloropicrin diluted with carbon tetrachloride per kilogram of comb in several days frees the latter completely of the moths. This procedure is more practical and more certain than methods of exposing the comb to the action of burning sulphur, sulphides, carbon tetrachloride, or dichlorobenzene. The solution employed is nonflammable.

JEFREMOW, N., and TICHOMIROWA, A. (235)
VERBINDUNGEN DER TETRYLS MIT KOHLENWASSERSTOFFEN. Ann. Inst. Analyse Physico-Chim. 4: 92–117. 1929. [Abstract in Chem. Zentbl. 1929 (1): 745. 1929.]

Chloropicrin with tetryl (tetranitromethylaniline) forms an easily melting mixture.

JOHNSON, M. O., and GODFREY, G. H. (236)
CHLOROPICRIN FOR NEMATODE CONTROL. Indus. and Engin. Chem. 24: 311–313. 1932.

Chloropicrin treatment of root knot (*Heteradera radicicola*) infested soils in pineapple fields of Hawaii have brought about striking reductions in infestation and equally striking increases in vigor of plant growth and in yield of pineapples. The most effective treatments were those which consisted of the introduction of chloropicrin in liquid form into holes 5 to 6 inches deep, spaced 18 inches apart and covered immediately with mulching paper, at the rate of 163 pounds or more per acre.

Pineapple plants treated with 180 pounds chloropicrin per acre yielded 20 tons per acre more pineapples than untreated plants. A tentative price of 65 cents per pound for chloropicrin in large quantities laid down in Honolulu was quoted by a Pacific coast firm.

KEKULE. A. (237)
UEBER DIE CONSTITUTION DES KNALLQUECKSILBERS. Ann. Chem. 101: 200–213. 1857.

Chloropicrin was obtained by the action of nitric acid and alcohol upon sodium chloride (p. 212).

KEKULE, A.—Continued. (238)
UEBER DIE CONSTITUTION UND DIE METAMORPHOSEN DER CHEMISCHEN VERBINDUNGEN UND UEBER DIE CHEMISCHE NATUR DES KOHLENSTOFFS. Ann. Chem. 106: 129–159. 1858.

Chloropicrin is obtained if solid or liquid chloral is distilled with concentrated nitric acid, or with a mixture of nitric and sulphuric acids; or if a mixture of wood alcohol and sulphuric acid is distilled with a mixture of saltpeter and sodium chloride (p. 144).

KEYES, F. G.. and MARSHALL, M. J. (239)
HEATS OF ADSORPTION OF SEVERAL GASES AND VAPORS ON CHARCOAL. Jour. Amer. Chem. Soc. 49: 156–173. 1927.

The heat of adsorption of chloropicrin on gas-mask charcoal is measured in an ice calorimeter (p. 160–161, 163–165).

KING, R. J. (240)
PROCESS FOR PRODUCING CHLOROPICRIN. U.S. Patent 1,327,714, issued January 13, 1920; applied for November 26, 1917.

King claims the process of producing chloropicrin which consists in forming an admixture of bleaching powder with water, wherein the amount of water is six times the equivalent of calcium oxide, and adding a solution of a calcium picrate.

KISS, D. (241)
ERKENNUNG DER KAMPFGASGEFAHR UND DER EINZELNEN KAMPFSTOFFE IM FELDE. Ztschr. Gesam. Schiess u. Sprengstoffw. 25: 260–262, 300–301. 1930.

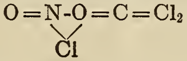
A discussion of physical, chemical and physiological methods of detecting war gases in the field. Chloropicrin has an irritant action at a concentration of 19 mg per cubic meter (p. 261).

KLAGES, A., and KNOEVENAGEL, E. (242)
UEBER DIHYDRO-S-CHLORXYLOL. Ber. Deut. Chem. Gesell. 28: 2044–2048. 1895.

Chloropicrin is one of the products obtained on boiling dihydro-s-chlorxylol with 30 percent nitric acid under a reflux condenser (p. 2045–2046).

KLING, A., and FLORENTIN, D. (243)
PROPRIÉTÉS ET CONSTITUTION DU GROUPEMENT ($OCCl_3$). Compt. Rend. Acad. Sci. [Paris] 172: 63–66. 1921.

Gardner and Fox have shown that chloropicrin decomposes slowly into nitrosyl chloride and phosgene, a reaction permitting the supposition that this body is susceptible of taking the tautomeric form



$$\underset{Cl}{O=N\text{-}O}=C=Cl_2$$

KLOSKY, S., and STRICKER, P. F. (244)
THE PHYSICO-CHEMICAL CONSTANTS OF CHLOROPICRIN. War Dept. [U.S.] Chem. Warfare Serv. Rpt. 61, p. 1–20. 1921.

The accepted values for chloropicrin are as follows: Boiling point, 112° C.; melting point, —69.2°; decomposition temperature, 150°; vapor pressure at 0°, 0.57 mm, at 20°, 18.2 mm; density at 0°, 1.6930, at 20°, 1.6579. Data are also given for latent heat of vaporization, specific heat, heat of reaction, heat of formation, and refractive index. A bibliography of 16 titles is appended.

KNISKERN, L. A. (245)
THE EFFECT OF CERTAIN CHEMICAL WARFARE GASES ON INSTRUMENTS AND MATERIALS OF WARSHIPS. Chem. Warfare 13 (7): 144–150. 1927.

Specimens of lead, shell steel, and Benedict steel showed excessive corrosion after immersion in liquid chloropicrin for 7 days or more (p. 145).

KNOLL, W. (246)
REIZSTOFFZUSÄTZE ZUR BLAUSÄURE BEI ENTWESUNGEN. Ztschr. Gesam. Schiess u. Sprengstoffw. 22: 294-296. 1927.

Chloropicrin is used alone and in mixtures with methyl bromoacetate as a warning agent in fumigation with hydrocyanic acid. In a comparative study of the toxic concentration of a number of gases of localized action, that of chloropicrin is given as 2,000 mg per liter. The intolerable concentration is 60 mm^3 per cubic meter (101 mg per cubic meter).

KOKATNUR, V. R. (247)
COMMERCIAL USES OF CHLORINE. Chem. and Metall. Engin. 19: 667–671. 1918.

More than 50 percent of the war gases are chlorine compounds. Chloropicrin is listed as a tear gas used in shells (p. 668).

KOONTZ, A. R. (248)
WHEN DO LUNGS RETURN TO NORMAL FOLLOWING EXPOSURE TO WAR GASES? Arch. Int. Med. 36: 204–219. 1925.

The effect of chloropicrin on the lungs of dogs is studied. There are no pathologic lesions and, while there may be a small amount of permanent lung damage, the small amount of resulting scar tissue can hardly affect the functional efficiency of the lungs. It is concluded that in the vast majority of surviving human patients, all lesions have disappeared within a short while after gassing, and that the small amount of fibrosis remaining in the minority of cases can hardly be a cause of serious disability. (p. 205, 214–216, 218).

KORAB, I. I. (249)
THE PEA AND THE PEA WEEVIL. Trud. Bilotzerk. Selektz. Sta. Belaya-Cerkov Plant Breed. Sta. Bul. 2 (4): 81–126. 1927. [Abstract in Rev. Appl. Ent. (A) 16: 219–220. 1928.]

The various methods of destroying this pest (*Bruchus pisorum* L.) in stored peas by fumigation with carbon bisulphide, hydrocyanic acid gas, or chloropicrin are discussed.

KOTATSU, K. (250)
MORBID CHANGE IN LUNG CAUSED BY INHALATION OF COKUSOL (CHLOROPICRIN) GAS AND EFFECT OF GAS ON TUBERCULOSIS. Bul. Nav. M. A. Japan 18: 1. 1929. [Listed in Quart. Cumulative Index Medicus 8: 316, 688. 1931.]

KUBELKA, P. (251)
THE VAPOR PRESSURE ISOTHERMS AND THE SUBMICROSCOPIC STRUCTURE OF ACTIVE CHARCOALS. Kolloid Ztschr. 55: 129–143. 1931. [Abstract in Chem. Abs. 25: 4164–4165. 1931.]

The capillary condensation of benzene, ether, chloropicrin, carbon dioxide, and water by 10 different charcoals, activated with zinc chloride, phosphoric acid, and steam, was determined at 20° by the dynamic method. At saturation pressures 1 liter of charcoal absorbed an equivalent of about 233 cc of liquid chloropicrin. The surface tension of chloropicrin is given as 36.2 dynes per square centimeter.

KUNIKE, G. (252)
ZUR LEBENSGESCHICHTE DES REISMEHLKÄFERS. TRIBOLIUM CONFUSUM. Mitt. Gesell. Vorratsschutz. 7 (1): 8–11. 1931.

Reference is made to the use of chloropicrin in America for combating *Tribolium confusum* (p. 11).

L., F. (253)
CORRESPONDENCE—CONSEILS PRATIQUES. Jour. Agr. Prat. 39 (6): 122. 1923.

Chloropicrin is recommended for the destruction of harmful insects and rats.

LAAKE, E. W., PARMAN, D. C., BISHOPP, F. C., and ROARK, R. C. (254)
FIELD TESTS WITH REPELLENTS FOR THE SCREW WORM COCHLIOMYIA MACELLARIA FAB. UPON DOMESTIC ANIMALS. Jour. Econ. Ent. 19: 536–539. 1926.

Chloropicrin diluted in lubricating oil, pine-tar oil, or a mixture of the two, in strengths of from 1 to 5 percent by volume, was an effective repellent against screw worms when applied to goats, sheep, and cattle. It did not injure the animals.

Laake, E. W., Parman, D. C., Bishopp, F. C., and Roark, R. C.—Contd. (255)
THE CHEMOTROPIC RESPONSES OF THE HOUSE FLY, THE GREEN-BOTTLE FLIES, AND THE BLACK BLOWFLY. U.S. Dept. Agr. Tech. Bul. 270, 11 p. 1931.

A mixture of 9 parts lubricating oil and 1 part chloropicrin repelled 85 percent of the houseflies and 79 percent of the green-bottle flies visiting treated beef-liver baits. The corresponding percentages when 49 parts lubricating oil were mixed with 1 part chloropicrin were 88 and 75 (p. 4).

Ladd, E. T. (256)
FUMIGATING DEVICE. U.S. Patent 1,819,900, issued August 18, 1931; applied for October 26, 1929. Assigned to Isco Chemical Co. (Inc.), Niagara Falls, N.Y.

The principal object of this invention is to provide a chest so designed that when the cover is closed a glass ampoule is broken, and a definite charge of liquid or gas is released within the chest. Chloropicrin is the preferred fumigant.

Lamb, A. B., Wilson, R. E., and Chaney, N. K. (257)
GAS MASK ABSORBENTS. Jour. Indus. Engin. Chem. 11: 420–438. 1919.

The service time of charcoal used in absorbing chloropicrin decreases with increase of temperature and drops very rapidly with increase in relative humidity. The typical absorptive values of different charcoals are shown for chloropicrin, phosgene, hydrocyanic acid, arsine, cyanogen chloride, trichlormethylchloroformate, and chlorine.

Lambert, R. A., and Jackson, L. (258)
THE PATHOLOGY OF CHLOROPICRIN POISONING. *In* Collected Studies on the Pathology of War Gas Poisoning, by M. C. Winternitz, p. 69–84. New Haven. 1920.

Chloropicrin injures the epithelium of the entire respiratory tract, especially the medium-sized and small bronchi. An overwhelming edema of the lungs rapidly follows exposure to a lethal concentration of the gas.

Lancelin, and Seguy, F. (259)
SUR L'EMPLOI DE LA CHLOROPICRINE AU PORT DE TOULON. Marseille Med. 63: 708–713. 1926.

The rubber joints of a Vermorel sprayer were so rapidly attacked by chloropicrin that in spite of careful rinsing after use the apparatus was rendered nonusable in 24 hours. The utilization of chloropicrin in fumigation is reduced to a problem of ventilation. It should not be used in the lower parts, especially the parts under the water line, of ships. A 700-ton boat was freed from rats by an application of chloropicrin at the rate of 15 g per cubic meter, but 7 full days were necessary to allow the boat to become habitable. In 1924 more than 20,000 cubic meters of space in hospital rooms, halls, etc., around Toulon were fumigated with chloropicrin without notable incident. The largest space fumigated was a 1,600-m^3 hall, which was treated with 10 liters of chloropicrin in order to get a concentration of 10 to 11 g per cubic meter. The liquid was thrown on the walls by two men supplied with gas masks. Ten minutes after opening the windows it was possible to enter without masks a 1,200-m^3 hall which had been fumigated with chloropicrin.

Lapazaran, J. C. (260)
UNA CAMPANA DE LANGOSTA EN ZARAGOZA. Bol. Agr. Tec. y Econ. 14: 599–608. 1922.

A mixture of carbonyl chloride and stannic chloride, which is considered very toxic to mammals, did not give good results against insects (*Dociostaurus maroccanus*), but a 50 percent emulsion of chloropicrin gave excellent results, proving fatal to every insect that was actually hit by the spray (p. 606).

Larson, A. O. (261)
PEA-WEEVIL CONTROL IN THE WILLAMETTE VALLEY. Oreg. Agr. Expt. Sta. Circ. 99, p. 5–12. 1931.

Chloropicrin has proved to be a very satisfactory fumigant for Austrian winter field peas on a commercial scale. As it is very tenacious and irritating to the mucous membrane, it can be used satisfactorily only where there are good facilities for ventilating the fumigatorium (p. 12).

LATYSHEFF, N. I., and TROITZKYA, N. V. (262)
RESULTS FROM USE OF CHLOROPICRIN FOR DESTRUCTION OF ORNITHODOROS PAPILLIPES, CARRIER OF RELAPSING FEVER. Med. Misl. Uzbek. I Turk. 5: 55–58. 1930. [Listed in Quart. Cumulative Index Medicus 9: 1185. 1931.]

LECAT, M. (263)
NOUVEAUX AZÉOTROPES. QUATRIÈME LISTE. Ann. Soc. Sci. Bruxelles (B) 47: 21–27. 1927.

Azeotropic mixtures formed with chloropicrin are given as follows: Approximately 35 percent chloropicrin (111.85°) + ethyl alcohol (78.3°), 77.4°; 33.5 percent chloropicrin + isopropyl alcohol (82.45°), 82.0°; 58.5 percent chloropicrin + propyl alcohol (97.2°), 94.0°; 67.5 percent chloropicrin + isobutyl alcohol (107.85°), 102.05°; 29 percent chloropicrin + methylcyclohexane (101.1°), 100.75°. Chloropicrin forms nonazeotropes with toluene and acetal.

——— (264)
NOUVEAUX AZÉOTROPES BINAIRES. CINQUIÈME LISTE. Rec. Trav. Chim. Pays-Bas 46: 240–247. 1927.

Chloropicrin forms positive azeotropes with allyl alcohol, dimethylethylcarbinol, normal butanol, and isobutylcarbinol. It forms a nonazeotropic system with methyl alcohol and normal hexanol (p. 243, 245).

LEFEBURE, V. (265)
THE RIDDLE OF THE RHINE. 279 p. London. 1921.

The following are given as examples of asphyxiating gases (those which produce their effect by causing lesions and congestion in the pulmonary system, causing death by suffocation): Chlorine, phosgene, diphosgene, chloropicrin, bromacetone, and diphenylchlorarsine. Chloropicrin was mixed with diphosgene and used in the familiar green cross shell. The production (by the Interessen Gemeinschaft in Germany) was very readily mastered and attained the rate of 200 tons per month.

LEHALLEUR, J. P. (266)
DESTRUICAO DOS PARASITAS EM AGRICULTURA COMO AUXILIO DA CHLOROPICRINA. Lavoura, Bol. Soc. Nac. Agr. [Brazil] 29: 133–135. 1925.

Describes the use of chloropicrin in France by Piedallu and others in fumigating grain, and its use in Italy for killing rats in ships. If chloropicrin were used to treat one tenth of the coffee plantations in Brazil (2,500,000 hectares), at the rate of 30 kg per hectare, 7,500 tons of chloropicrin would be required. The insect *Stephanoderes coffeae* in Brazil was treated by Lehalleur with chloropicrin.

LEHRECKE, H. (267)
UEBER DIE WIRKSAMKEIT VON AUGENREIZSTOFFEN UND IHRE ANWENDUNG IN DER SCHÄDLINGSBEKÄMPFUNG MIT BLAUSÄURE. Centbl. Bakt. [etc.] 102 (1): 111–119. 1927.

In choosing a warning substance for addition to hydrocyanic acid one must consider specific gravity, boiling point, volatility, safety, and ability to attract attention. Chloropicrin is one of the substances found to be satisfactory (p. 113–119).

——— (268)
WARNING MEANS FOR POISON GASES. U.S. Patent 1,786,623, issued December 30, 1930; applied for June 24, 1926; in Austria July 18, 1925.

Claim is made for the method of fumigation which comprises employing vapors of hydrocyanic acid having sufficient chloropicrin vapors admixed therewith to act as a warning agent.

A liquid mixture of 10 percent chloropicrin and 90 percent hydrocyanic acid is suitable for absorbing in active charcoal or kieselguhr. For spraying, a mixture containing 5 percent chloropicrin is suitable. Bromobenzene and an additional warning agent may in some cases be admixed with the chloropicrin. The chloropicrin may be sprayed or otherwise released in the space to be treated before, after, or simultaneously with the hydrocyanic acid.

LEISER, R. (269)
ELEKTRISCHE DOPPELBRECHUNG DER KOHLENSTOFFVERBINDUNGEN. Abhandl. Deut. Bunsen-Gesell. Angew. Phys. Chem. No. 4, p. 1–71. 1910.

The Kerr constant $100\frac{B}{B_0}$ for chloropicrin is —55.7 (p. 70).

LEITNER, K. (270)
LA DÉSINTOXICATION DE L'EAU CONTAMINÉE PAR LES GAZ. Rev. Internatl. Croix-Rouge 11(125) 332–334. Geneve. 1929. (Bul. Internatl. Soc. Croix-Rouge v. 60, no. 321.)

At ordinary temperature chloropicrin is soluble in water to the extent of 210 to 220 mg per liter.

Chloropicrin is not readily hydrolyzed by water but is easily decomposed by liver of sulphur. After having separated the liquid chloropicrin from water by mechanical means, all the chloropicrin with the sulphur may be retained by filtration with an absorbent charcoal.

LESNE, P. (271)
L'UTILISATION DE LA CHLOROPICRINE POUR LA DESTRUCTION DES INSECTES NUISIBLES ET DES RATS. Jour. Agr. Prat. 33: 462–464. 1920.

Describes the work of Bertrand in France and of Piutti and Bernardini in Italy with chloropicrin.

LEVY, J. (272)
CHLOROPICRIN FOR KILLING PARASITES OF COTTON SEEDS. Bol. Reparto Fibre Tessili Staz. Sper. Ind. Carta 3: 102–105. 1931. [Abstract in Chem. Abs. 26: 1700. 1932.]

A portable apparatus is described for the disinfection of cottonseeds with a current of air containing chloropicrin.

LEVY, S., and JEDLICKA, K. (273)
UEBER SPALTUNGSPRODUCTE DER CHLOR-, BROM-, UND NITRANILSÄURE. Ann. Chem. 249: 66–98. 1888.

Chloropicrin is obtained by the action of chlorine gas upon the sodium salt of nitranilic acid in the presence of water and iodine (p. 86).

LIGNIERES, J. (274)
SOBRE LOS METODOS PARA LA DESTRUCCION DE LA LANGOSTA, DE ALGUNOS COLEOPTOROS Y OTROS PARASITOS DE LA AGRICULTURA. Rev. Agr. [Mex.] 6: 479–484. 1921.

A description of the experiments of Bertrand and others with chloropicrin.

LINGLER, H. G.m.b.H.
PROCÉDÉ DE CONSERVATION ET DE TRANSPORT DE PRODUITS ANTI-PARASITES. French Patent 681,887, issued May 20, 1930; applied for September 17, 1929.

Volatile insecticides, such as hydrogen cyanide, cyanogen chloride, ethylene oxide, and chloropicrin, are preserved and transported in receptacles from which the oxygen has been removed by evacuation or by replacement with an inert gas, such as carbon dioxide and nitrogen, or with the vapor of the material itself.

LORMAND, C. (276)
EMPLOI DE LA CHLOROPICRINE POUR LA DESTRUCTION DES RENARDS. Compt. Rend. Acad. Agr. France 7: 568–570. 1921.

Encouraging results have been obtained in tests with chloropicrin for the destruction of foxes. The openings to the fox's burrow should be carefully plugged, except the one for the introduction of the chloropicrin. A half liter of chloropicrin should be poured in and the opening immediately closed. When using chloropicrin in this way one should be supplied with a mask.

LUSTIG, A. (277)
LA CHIMICA IN GUERRA E I GAS ASFISSIANTI. Ital. Sanit. 16: 9–12. 1924.

A list of gases used in the war is given. Chloropicrin is described as an irritating lachrymatory and asphyxiating gas (p. 11).

Lutrario, A. (278)

NOTE SUR L'EMPLOI DE L'ACIDE CYANHYDRIQUE DANS LES SERVICE DE PROPHYLAXIE. Off. Internatl. Hyg. Pub. [Paris], Bul. Mens. 12: 484–492. 1920.

For the destruction of rats in ships, chloropicrin, phosgene, and hydrocyanic acid have been used. For chloropicrin a special apparatus is necessary; exposure for at least 3 hours is required, and no effect is produced upon fleas at the minimum concentration necessary for the destruction of the rodents (1.07 cc per cubic meter). The use of a gas mask is indispensable in handling this material (p. 484–485).

Macbeth, A. K., and Pratt, D. D. (279)

THE LABILE NATURE OF THE HALOGEN ATOMS IN SUBSTITUTED NITROMETHANES. Jour. Chem. Soc. [London] 119: 1358–1359. 1921.

The following reaction takes place slowly: $2CCl_3NO_2+N_2H_4+4KOH=2CCl_2KNO_2+2KCl+N_2+4H_2O$.

McCowen, G. R. (280)

SOME MEDICAL PROBLEMS IN CONNECTION WITH CHEMICAL WARFARE. Jour. Roy. Naval Med. Serv. 9: 169–182. 1923.

A lecture. Mentions chloropicrin as used in shells and as a good but very poisonous insecticide.

McDonnell, C. C. (281)

RECENT PROGRESS IN INSECTICIDES AND FUNGICIDES. Indus. and Engin. Chem. 16: 1007–1012. 1924.

Reference is made to unpublished results of work by Roark and Bishopp, which show that chloropicrin is a powerful repellent against the screw worm, and that when mixed with lubricating oil, 1 to 100, and applied to wounds on goats no injury to the animals results and quick healing is obtained (p. 1010).

Magana, J. B. (282)

LOS GORGOJOS DE LAS LEGUMINOSAS. Rev. Agr. Trop. [Salvador] 1: 621–625. 1921.

The work of Bertrand, who found that an exposure of 5 to 10 minutes in an atmosphere containing from 1 to 2 cg of chloropicrin per liter was fatal to granary weevils, is briefly referred to.

Malpeaux, L. (283)

LA CONSERVATION DES GRAINS. LES ENNEMIS DES GRAINS EN MAGASINES. Vie Agr. et Rurale 17: 315–317. 1920.

Granary weevils may be destroyed by heat, sulphur dioxide, carbon disulphide, or chloropicrin. The properties and method of application of chloropicrin for destroying grain pests is described. The work of Piutti and Bernardini is referred to.

Mandouil, A. H. (284)

SUR LA DERATISATION DES NAVIRES. EMPLOI DE LA CHLOROPICRINE. Jour. Med. Bordeaux 96: 660–661. 1924.

The use of hydrocyanic acid and sulphur dioxide in killing rats on ships is discussed. Chloropicrin should be applied by spraying, after which the fumigated space is ventilated by means of a powerful, mobile, motor-driven air exhauster. Mention is made of a report by Degoul in 1923 entitled "Contribution a l'étude de la deratisation des navires", which states that chloropicrin should be used to rid ships of rats only when an almost perfect kill is desired, as, for example, when the ship is contaminated with the plague.

Manieri, A., and Morelli, E. (285)

SULLE VARIAZIONI DEL CONTENUTO IN ADRENALINA NELLE SURRENALI DI ANIMALI SOTTOPOSTI ALL' AZIONE DI ALCUNI TOSSICI DI GUERRA. Lo Sper. 83: 45–62. 1929.

The adrenals of guinea pigs killed by asphyxiation with chloropicrin, phosgene, or diphenylchloroarsine showed an increase in adrenaline.

MANKIN, G. H. (286)
GAS POISONING IN WARFARE. U.S. Naval Med. Bul. 15, p. 775–783. 1921.

Chloropicrin is a lung irritant. It was introduced by the Germans in shells in July 1916. Statistics of gas casualties during the war are given (p. 780).

MARCANDIER. (287)
RECHERCHES SUR L'ACTION ANTISEPTIQUE ET INSECTICIDE DES VAPEURS DE CHLOROPICRINE. Arch. Méd. et Pharm. Nav. 118: 138–166. 1928.

A summary is given of the physico-chemical properties of chloropicrin. Its action on cats, guinea pigs, rats, and rabbits is discussed. Its antiseptic action is studied, *Bacillus coli*, *B. subtilis*, Staphylococci, and Streptococci being used.

MARCHAL, P. (288)
RAPPORT PHYTOPATHOLOGIQUE POUR LES ANNEES 1919–1920—PAR LE DIRECTEUR DE LA STATION ENTOMOLOGIQUE ET DE DIRECTOR DE LA STATION DE PATHOLOGIE VEGETALE DE PARIS. Ann. Epiphyties 7: 1–87. 1921.

The work of Bertrand, Piutti, and Bernardini, Feytaud (*142*) and Vayssiere with chloropicrin is briefly referred to (p. 6–7).

——— (289)
RAPPORTS SOMMAIRES SUR LES TRAVAUX ACCOMPLIS DANS LES LABORATORIES ET COMPTES RENDUS DES MISSIONS D'ÉTUDES. Ann. Epiphyties 8: 315–316. 1922.

The work of Vayssiere in fumigating cottonseed infested with *Pectinophora* [*Gelechia*] *gossypiella* is discussed. Chloropicrin at the rate of 30 g per cubic meter, with 24 hours' exposure, killed all insects without altering the germination of the seed (86.5 percent for the treated seed, 89 percent for the untreated). Potatoes infested with *Phlorimaea operculella* were treated with chloropicrin at the rate of 30 g per cubic meter, with a 24-hour exposure. This killed 100 percent of the insects. Woodwork attacked by the wood-eating insects, *Criocephalus rusticus*, *Hylotrupes bajulus*, *Sirex juvencus*, was fumigated with chloropicrin, with perfect results.

——— and VAYSSIERE, P. (290)
ETUDE SUR LA DESINFECTION DES PRODUITS VEGETAUX ET DES DENREES AGRICOLES. Ann. Epiphyties 11: 121–183. 1925.

The work of Bertrand, Moore, Neifert and Garrison, Faes, Vayssiere, Piedallu, Miege, and Trouvelot and Schindler is mentioned. In 1924 several tons of American seeds destined for French West Africa were treated at Bordeaux with chloropicrin, with good insecticidal results and without injuring germination (p. 135–136).

MARLAND, L. (291)
GAZES DE COMBATE. Rev. Med. Hyg. Mil. (Rio de Janeiro) 8: 179–188, 242–251, 343–345. 1922.

The war gases used by Germany are listed in the order of their appearance (p. 188). Chloropicrin is described as a suffocating gas (p. 242).

MASON, F. A. (292)
THE KHAPRA BEETLE IN BRITISH MALTINGS. Bur. Bio-Technol., Leeds, Bul. 13, p. 118–123. 1924.

Of the fumigants tried, chloropicrin has yielded the most certain results against the Khapra beetle (*Trogoderma granarium* Everts).

MATRUCHOT, L., and SEE, P. (293)
ACTION DE LA CHLOROPICRINE SUR DES MOISISSURES DIVERSES. Compt. Rend. Soc. Biol. [Paris] 83: 170–171. 1920.

The following fungi growing in culture tubes were killed by exposure for 8 hours to an atmosphere saturated with chloropicrin: *Nocardia*, *Mucor mucedo*, *Penicillium*, *Amblyosporium*, *Hypomyces ochracea*, *Botrytis cinerea*, *Chaelomium bostrychodes*. Ten centigrams (0.10 g) of chloropicrin per liter of air killed all fungi in 48 hours except *Amblyosporium*, and this was killed in 42 hours with a double dose (0.20 g per liter).

MATTHEWS, A. (294)
PARTIAL STERILISATION OF SOIL BY ANTISEPTICS. Jour. Agr. Sci. [England] 14: 1–57. 1924.

A cucumber soil was treated with M/50 chloropicrin, which killed all the protozoa except a few flagellates. By the thirteenth day the bacteria were reduced by 50 million, but by the fifty-seventh day they had returned to control level, approximately where they remained for the next 80 days, the number of species being reduced at the same time. Treatment with other reagents equally fatal to protozoa, such as toluene, results in a great increase of bacteria above the control. The failure of chloropicrin to produce the same result is due to the very low food value of chloropicrin, the larger part of which consists of unoxidizable substances.

MATTHEWS, D. J. (295)
REPORT ON THE WORK OF THE W. B. RANDALL RESEARCH ASSISTANT FROM OCTOBER 1, 1918, TO DECEMBER 31, 1919. Expt. and Research Sta., Cheshunt, Herts, Ann. Rpt. 5: 18–21. 1919.

The addition of chloropicrin to the soil in pots containing tomatoes caused an increase in yield of 857 to 1,480 g. Against fungi, chloropicrin is said to be practically useless; against eelworms and wireworms it is most effective; and it is beneficial to bacterial activity. The practical difficulties of the application of chloropicrin have not been completely surmounted.

——— (296)
REPORT OF THE WORK OF THE W. B. RANDALL ASSISTANT. Expt. and Research Sta., Cheshunt, Herts, Ann. Rpt. 6: 45–51. 1920.

Chloropicrin injected into the soil by means of a Vermorel injector, at the rate of 10 hundredweight per acre, remained in the soil for a long time and proved fatal to Heterodera (root knot or eelworm). But it seemed to have no adverse effect on fungi, nor does it stimulate the bacterial growth. In one of the nurseries, chloropicrin, which caused the roots to be free from eelworm, gave a smaller crop of tomatoes than the badly clubbed plants from plots treated with carbolic acid, formaldehyde, 0.5 percent lime, or dichlorocresol. In pots treated with chloropicrin the gain in fruit (tomatoes) was 60 percent, and there was a remarkable stimulation of root growth (p. 48, 49, 51).

MAYER, A. (297)
MODE D'ACTION DES GAZ DE COMBAT UTILISES AU COURS DE LA GUERRE. Compt. Rend. Acad. Sci. [Paris] 170: 1073–1075. 1920.

The author classifies bromoketones, methylchlorosulphate, phosgene, chloromethyl chloroformate, and chloropicrin as suffocating compounds. These cause edema, which results in an asphyxiating action (p. 1074).

MAYER, A., PLANTEFOL, and VLES, F. (298)
SUR L'INTOXICATION PAR LES METHANES NITRO-HALOGENES. Compt. Rend. Acad. Sci. [Paris] 171: 1396–1397. 1920.

Of the nitro-halogenated methanes, chloropicrin is the most powerful in provoking edema; bromopicrin and dichlorodinitromethane are 8 to 10 times less active.

MEIER, R. (299)
ÜBER "REIZWIRKUNG" AN EINZELZELLEN. Arch. Expt. Path. u. Pharmakol. 122: 129–158. 1927.

The irritating effect of chloropicrin on the blood corpuscle of the goose and on the yeast cell (mold distillery and bottom yeasts) is studied. In the former there is no increase in respiration; in the latter case respiration is inhibited, and fermentation is stimulated (p. 136, 137, 146, 152, 153, 158).

MERCANDIER, M. (300)
RECHERCHES SUR POUVOIR INSECTICIDE ET BACTERICIDE DE LA CHLOROPICRINE. Jour. Med. Bordeaux 54: 665–672. 1924.

Chloropicrin at the rate of 10 to 20 g per cubic meter kills fleas and nits in most cases. Heat favors the action of the insecticide. Chloropicrin at the rate of 10 to 20 g per cubic meter, at 18 to 21° C., in 48 hours kills butterflies and larvae of *Tineola biselliella*, *Tinea pellionella*, and *Trichophaga tapetzella*. Ten grams of chloropicrin per cubic meter at 16° C. for 24 hours killed nearly all *Ectobia livida* exposed to it. Chloropicrin is bactericidal to *Bacillus coli* and Streptococcus. A saturated atmosphere of

MERCANDIER, M.—Continued.

RECHERCHES SUR POUVOIR INSECTICIDE ET BACTERICIDE DE LA CHLOROPICRINE—continued.

chloropicrin kills the Koch bacillus in less than 24 hours in the light and at the temperature of the laboratory. The anthrax spore is killed in a saturated atmosphere of chloropicrin in from 6 to 14 hours at 17 to 18° C. *B. subtilis* is only slightly attacked after 48 hours in a saturated atmosphere of chloropicrin.

MERRILL, E. D. (301)

ENTOMOLOGY. Calif. Agr. Expt. Sta. Ann. Rpt. 1927–1928, p. 32–33. 1929.

"Fumigation investigations during the past year have included the testing of materials other than cyanides, such as carbon tetrachlorid, ethyl acetate, ethylene dichlorid, ethylene oxide, vinyl chlorid, nicotine, carbon disulfid, and chloropicrin. Some of these materials have been recommended for certain types of fumigation, but for citrus fumigation none of them approaches cyanide for availability. A satisfactory citrus tree fumigant must be sufficiently toxic to kill insects under canvas covers with an exposure not to exceed one hour, and at the same time not injure the citrus tree. From the standpoints of both insect toxicity and tree tolerance hydrocyanic acid proved to be greatly superior to any of the materials indicated. Chloropicrin was the most toxic with a ratio of 1 to 3 as compared with liquid HCN on the red scale, but the plant tolerance was much less, and in addition the fact that it is a tear gas is objectionable, when it is used out of doors on a large scale."

METAIS, R. P. A. (302)

DE LA DESINSECTISATION DES LOCAUX. These, 92 p. Nancy. 1923.

The physical and chemical properties of chloropicrin are described briefly, and the work of Bertrand, Seguy, Randier, and others is referred to. A dosage of from 5 to 10 g of chloropicrin per cubic meter is recommended. The operator should be protected with an A. I. S. Mask. The destruction of bedbugs with a dose of 8.3 g of chloropicrin per cubic meter, the exposure being 24 hours, is described (p. 30–35).

METCALF, C. L., and FLINT, W. P. (303)

DESTRUCTIVE AND USEFUL INSECTS, THEIR HABITS AND CONTROL. 918 p. New York. 1928.

Chloropicrin, nitrobenzene, and mixtures of chlorine, carbon tetrachloride, ethyl acetate, and other gases have been used to some extent in insect fumigation. The use of these materials is still in the experimental stage (p. 260).

MEYER, J. (304)

DER GASKAMPF UND DIE CHEMISCHEN KAMPFSTOFFE. 424 p., illus. Leipzig. 1925.

Based on information from the literature, the physical, chemical, and toxicological properties of chloropicrin are briefly described (p. 363–367). Chloropicrin is also mentioned on pages 50, 60, 91, 97, 107, 135, 153, 163, 198, 204, 230, 259, 289.

MIEGE, E. (305)

ACTION DE LA CHLOROPICRIN SUR LA FACULTÉ GERMINATIVE DES GRAINES. Compt. Rend. Acad. Sci. [Paris] 172: 170–173. 1921. Jour. Agr. Prat. 35: 108. 1921.

Linseed and the seed of leguminous plants are not affected by chloropicrin fumigation, but hemp, beet, and cereals are adversely affected. Under the conditions necessary for fumigation the germination power of wheat may be diminished 30 percent. For the destruction of the insects it is necessary to use from 15 to 20 cc chloropicrin per cubic meter with a 24-hour exposure.

MILES, H. W. (306)

INVESTIGATIONS ON THE CONTROL OF THE KHAPRA BEETLE (TROGODERMA GRANARIUM EVERTS) WITH CALCIUM CYANIDE. Bul. Ent. Research 18 (3): 251–254. 1928.

Reference is made to experiments by Voelkel (*505*) on the Khapra beetle with hydrocyanic acid, chloropicrin, and tetrachloroethane, all of which proved toxic to both adults and larvae (p. 251).

Mills, E. J. (307)
on nitro-compounds (part i). Jour. Chem. Soc. [London] 17: 153–164. 1864.

Chloropicrin heated with fuming hydriodic acid in a sealed tube yields ammonia, but no methylamine.

——— (308)
on the nitration of chloroform. Jour. Chem. Soc. [London] 24: 641–642. 1871.

Chloropicrin is formed by heating 16 volumes of nitric acid containing much nitrogen peroxide in a sealed tube at 90° to 100° C. for 120 hours with 7 volumes of chloroform.

Mirguet. (309)
desinsectisation par la chloropicrine. Arch. Med. Pharm. Naval 110: 448–450. 1920.

Chloropicrin, at the rate of 5 g per cubic meter, kills fleas in clothing, beds, and elsewhere. Good results have also been obtained with chloropicrin against the parasites of fur.

Monjo, F. (310)
liquide insecticide et de mode de fabrication. French Patent 644,9[illegible]4, issued October 17, 1928; applied for August 11, 1927.

Chloropicrin or dichlorobenzene, separate or mixed, are dissolved in an organic solvent, and this solution is then emulsified in water by means of soap, saponin, or alkaline sulphoresinate for use as a liquid insecticide.

Moore, W. (311)
volatility of organic compounds as an index of the toxicity of their vapors to insects. Jour. Agr. Research 10: 365–371. 1917.

In general, the toxicity of a volatile organic compound is correlated closely with its volatility. A decreasing volatility is accompanied by an increased toxicity. The boiling point of the chemical is a general index of its volatility. Compounds with boiling points of 225° to 250° C. are usually so slightly volatile that they do not produce death except after very long exposures. Carbon disulphide, ethyl mercaptan, and particularly chloropicrin are more toxic than their volatilities would indicate. Chloropicrin vapor in a flask kills house flies (*Musca domestica* L.) in 400 minutes, with only 1.7 millionths of a gram molecule concentration.

——— (312)
fumigation with chloropicrin. Jour. Econ. Ent. 11: 357–362. 1918.

Molecule for molecule, chloropicrin is about 283 times as toxic as carbon disulphide to insects. One half pound of chloropicrin per 1,000 cubic feet is destructive to the bean weevil (*Bruchus obtectus* Say), the Angoumois grain moth (*Sitotroga cerealella* Oliv.), the Indian meal moth (*Plodia interpunctella* Hbn.), and the Mediterranean flour moth (*Ephestia kuehniella* Zell.), but is not sufficient to kill the confused flour beetle (*Tribolium confusum* Duval) deeper than 1 inch in the flour. For this insect it is necessary to use as much as 1 or 2 pounds per 1,000 cubic feet. Small doses, such as one half pound per 1,000 cubic feet of space, do not injure the germination of grain, but large doses do, if germination is attempted before the grain has had a very thorough airing. It is also essential that the grain be perfectly dry when fumigated. Flour fumigated with chloropicrin at the rate of 2 pounds per 1,000 cubic feet for 24 hours at 70° F. was adversely affected, even after thorough airing for 1 week. The fumigated sample required 35 minutes longer for fermentation than the control. Chemically pure chloropicrin does not bleach fabrics when used at the rate of 2 pounds per 1.000 cubic feet. The manufacture of chloropicrin for about 30 cents per pound is believed possible.

——— (313)
methods of control of the clothes louse (pediculus [vestimenti] humanus). Jour. Lab. and Clin. Med. 3: 261–268. 1918.

Clothing can be piled into a galvanized-iron ash tin, chloropicrin sprinkled through at the rate of 4 cc to the cubic foot, and in 15 minutes all lice will be dead, and a half hour's fumigation is sufficient to kill eggs in all stages

MOORE, W.—Continued.

METHODS OF CONTROL OF THE CLOTHES LOUSE, ETC.—continued.

of development. In order to kill the eggs by fumigation in 30 minutes, a small amount of heat is necessary to hasten the evaporation of the chloropicrin. To each cubic foot of space one liter flask filled with water heated to 80° C. was used in the experiments.

——— and CAMPBELL, F. L. (314)

STUDIES ON NONARSENICAL STOMACH-POISON INSECTICIDES. Jour. Agr. Research 28: 395–402. 1924.

Wild cherry foliage and tomato plants were dusted with silica gel and charcoal on which chloropicrin was adsorbed. The percentage of chloropicrin in silica gel was 20, and in charcoal 35. There was no injury to the foliage; neither were any tent caterpillars or Colorado potato beetles feeding on the foliage killed.

——— and GRAHAM, S. A. (315)

PHYSICAL PROPERTIES GOVERNING THE EFFICACY OF CONTACT INSECTICIDES. Jour. Agr. Research 13: 523–538. 1918.

Chloropicrin is very effective in penetrating the trachea of the cockroach (*Blattella* [*Phyllodromia*] *germanica* L.). Its abnormal toxicity is ascribed to its ability to be absorbed by the chitin and passed into the body.

——— and GRAHAM, S. A. (316)

TOXICITY OF VOLATILE ORGANIC COMPOUNDS TO INSECT EGGS. Jour. Agr. Research 12: 579–587. 1918.

All Colorado potato-beetle eggs (*Leptinotarsa decemlineata Say.*) dipped in or sprayed with chloropicrin failed to hatch. A concentration of chloropicrin vapor of only 2.8 millionths of a gram molecule killed these eggs in a 15-hour exposure. In general, compounds with high boiling point and slight volatility are more effective in dipping and spraying insect eggs than compounds with low boiling point and high volatility. The toxicity of the vapor of organic compounds to insect eggs is related to the boiling point and the volatility. As the boiling point increases and the volatility decreases the toxicity increases.

——— and HIRSCHFELDER, A. D. (317)

AN INVESTIGATION OF THE LOUSE PROBLEM. Minn. Univ. Research Pub. v. 8, no. 4, 86 p. 1919.

Garments were fumigated in an ordinary galvanized-iron ash can without special efforts to make it airtight. A small amount of heat is necessary in order to evaporate chloropicrin rapidly so that it may penetrate all parts of the clothing and destroy the eggs of the lice within 30 minutes. Eggs are more difficult to destroy than the active forms. Ten cc of chloropicrin to 2.5 cubic feet with a 30-minute exposure, heated by three 1-liter flasks of water at 80° C., gave good results. Airing the clothing in the open for 3 to 5 minutes is sufficient to remove the chloropicrin, after which the clothing can be worn. It is necessary for the operator to wear a gas mask. No bleaching or fading of colored fabrics was observed in a number of tests made with fabrics of delicate coloring, provided the chloropicrin contained no impurities of chlorine or nitrogen peroxide. No injurious effect on leather was observed, but rubber is injured somewhat, although not as much as might be expected (p. 26–33).

MORELLI, E. (318)

SULLE MODIFICAZIONI ISTOLOGICHE DELLA TIROIDE DI ANIMALI SOTTOPOSTI ALL'AZIONE DI ALCUNI GAS ASFISSIANTI. Sperimentale 80: 371–393. 1926.

Structural thyroid changes in animals treated with chloropicrin indicate an initial hyperactivity, followed by marked hypofunction with epithelial degeneration. In the case of repeated exposures of short duration, only the hyperactive state was detected (p. 378–384, 386–392).

MORGENTHALER, O. (319)

PROBLEMS OF ACARINE DISEASE OF BEES. Bee World 10 (2): 19–24. 1929.

Beehives infested with acarine disease were fumigated with chloropicrin according to the directions of Dr. Rennie. Chloropicrin had no effect, but sulphur vapors appeared very promising in destroying this infection.

MOUREU, C. (320)
CHIMIE DE GUERRE LES GAX DE COMBAT. Rev. Sci. [Paris] 58: 321–333. 1920.

Chloropicrin was first used by the Germans in May 1917. It was made by the French by the action of chloride of lime on picric acid, and 500 metric tons were produced.

——— (321)
LA CHIMIE ET LA GUERRE: SCIENCE ET AVENIR. 384 p. Paris. 1920.

Chloropicrin was first used by the Germans on the field of battle in May 1917. The use of chloropicrin was suggested in June 1915, by Haller and Moureu (p. 65). Chloropicrin was prepared by the action of chloride of lime upon picric acid, and 500 metric tons were produced (p. 77).

MÜLLER, K. (322)
BEITRÄGE ZUR KENNTNIS DES KORNKÄFERS CALENDRA GRANARIA L. Ztschr. Angew. Ent. 13: 313–374. 1927–1928.

Reference is made to the use of chloropicrin as a fumigant by Bertrand (*50, 59, 60*), Piutti (*364*), Miege (*305*), Wille (*520, 521, 522*), and Burkhardt (*87*).

MÜNDER, W. (323)
INSEKTEN-VERTILGUNGSMITTEL. Seifensieder-Ztg.-Chem.-Techn. Fabrikant 26 (17): 57–60. Augsburg. 1929.

A general discussion of insecticides with numerous formulas, especially for household insecticides.

A mixture of equal volumes of carbon tetrachloride and chloropicrin sprayed into a room should serve as a general insecticide (p. 60).

NABOKOW, W. A., and SOLOWIEW, W. W. (324)
DISINFECTION OF DWELLINGS WITH CHLOROPICRIN. Russ. Jour. Trop. Med. 7 (5): 354–356. 1929.

Chloropicrin is recommended for the disinfection of dwellings. It affects metals only at high relative humidity. Most textiles and dyes are not affected by it. It kills at a relatively low concentration and in a short time most of the insects which are important from a sanitary standpoint. Studies on the use of chloropicrin as a disinfectant are in progress.

NARUMO, N. (325)
ON A METHOD OF CONTROLLING WHITE GRUBS IN LAWNS. Oyo-Dabuts.-Zasshi 2: 140. 1930. [In Japanese. Abstract in Rev. Appl. Ent. (A) 18: 614. 1930.]

An emulsion of 250 cc of chloropicrin, 160 cc of water, and 7.5 g of soap, used at the rate of 150 cc in 180 l of water, over an area of 10 square meters, killed Lamellicorn larvae in lawns but injured the grass.

NATIONAL RESEARCH COUNCIL. (326)
INTERNATIONAL CRITICAL TABLES OF NUMERICAL DATA, PHYSICS, CHEMISTRY AND TECHNOLOGY, v. 1, 415 p., illus. New York and London. 1926.

Data on the molecular weight, melting point, boiling point, and specific gravity of chloropicrin are given on p. 176, and the refractive index is given on p. 277.

NEIFERT, I. E., COOK, F. C., ROARK, R. C., TONKIN, W. H., BACK. E. A., COTTON, R. T. (327)
FUMIGATION AGAINST GRAIN WEEVILS WITH VARIOUS VOLATILE ORGANIC COMPOUNDS. U.S. Dept. Agr. Bul. 1313. 40 p., illus. 1925.

Chloropicrin is mentioned as a material which has been tested as a fumigant for granary weevils (p. 2).

——— and GARRISON, G. L. (328)
EXPERIMENTS ON THE TOXIC ACTION OF CERTAIN GASES ON INSECTS, SEEDS, AND FUNGI. U.S. Dept. Agr. Bul. 893. 16 p. 1920.

The effect of various concentrations (0.5 to 1.75 percent) of chloropicrin vapor at a temperature of 20 to 27° C. and at a relative humidity of 40 was tried upon the following insects: Ants (*Monomorium pharaonis* L.), NEIFERT, I. E., and GARRISON, G. L.—Continued.

EXPERIMENTS ON THE TOXIC ACTION OF CERTAIN GASES ON INSECTS, SEEDS, AND FUNGI—continued.

aphids (*Myzus persicae* Sulz.), bedbugs (*Cimex lectularius* L.), flat grain beetles (*Laemophloeus minutus* Oliv.), potato flea beetles (*Epitrix cucumeris* Harris), saw-toothed grain beetles (*Oryzaephilus* [*Silvanus*] *surinamensis* L.), grain borers (*Rhizopertha dominica* Fab.), house flies (*Musca domestica* L.), white-flies (*Aleyrodes vaporariorum* Westw.), Phyllostachys bamboo mites (*Tarsonemus* sp.), roaches (*Blattella* [*Phylladromia*] *germanica* L.), common red spiders (*Tetranychus bimaculatus* Harvey), flour weevils (*Tribolium ferrugineum* Fab.), and rice weevils (*Calendra* [*Sitophilus*] *oryza* L.). In general, chloropicrin is more poisonous than HCN to stored-product insects. Mites, however, appear more resistant to chloropicrin than to hydrocyanic acid. Apparently chloropicrin stimulates the growth of rice and timothy and injures somewhat the seeds of alfalfa and radishes. Other seeds show no marked effects. These germination tests were made on seeds exposed for from 30 minutes to 2 hours to a 1.75 percent concentration of chloropicrin at 20° C., relative humidity, 0. The results of a series of experiments on Fusarium, Ascochyta, Penicillium, and Colletotrichum indicate that chloropicrin cannot be used as a fungicide. Chloropicrin vapor has a very slight corrosive effect on brass, steel, galvanized iron, copper, and zinc. Painted and varnished surfaces are not visibly affected by exposure to chloropicrin vapor.

NEKRASSOW, W., and MELNIKOW, N. N. (329)

ÜBER DIE EINWIRKUNG VON CHLORPIKRIN AUF MERCAPTANE. Ber. Deut. Chem. Gesell. (B) 62: 2091–2094. 1929.

Chloropicrin oxidizes mercaptans to disulphides. The main action is represented by the equation $2(RS)_3CNO_2=3R_2S_2+2CO_2+N_2$ and is accompanied to a slighter extent by the reaction $2(RS)_3CNO_2=3R_2S_2+2CO+2NO$. The reaction with the free mercaptans is very slow, but the potassium mercaptides react immediately, even in the cold, and as the resulting disulphides are practically insoluble in water the reaction can be used to detect traces of chloropicrin in aqueous solutions. Phenylmercaptan is especially well adapted for this purpose. With 0.01 mg. of chloropicrin in 1 cc of water made faintly alkaline a few drops of alcoholic phenylmercaptan produce an opalescence and, with higher concentrations, a precipitate.

NEUWIRTH, F. (330)

ÜBER ELEKTROMETRISCHE FESTSTELLUNG DER VITALITÄT DES PFLANZLICHEN GEWEBES UND DAS MESSEN DER TOXIZITÄT EINIGER GEGENÜBER DER RÜBE. (Vorläufige Mitteilung.) Ztschr. Zuckerindus. Cechoslovak. Repub. Rpt. 50: 129–130. 1925.

The effect of a number of substances on the conductivity of an electric current through sugar-beet tissues is studied. Sulphurous acid and ammonia raised the conductivity much more quickly than chloropicrin.

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ELECTROMETRISCHE FESTSTELLUNG DER "VITALITÄT" DES PFLANZLICHEN GEWEBES UND MESSEN DER TOXIZITÄT EINIGER GIFTE GEGENÜBER DER RÜBE. Ztschr. Zuckerindus. Cechoslovak. Repub. Rpt. 51: 249–257. 1927. Also in Listy Cukrovarnicke 45: 61ff. 1926–27.

Electrometric determinations are made of the vitality of sugar-beet tissues, resistance of both healthy beets and of dead tissues being read. The effect of higher temperatures and of a number of substances on the conductivity of live tissue is studied. Chloropicrin has little or no effect in 10 hours. Chloropicrin, although a strong poison for animals, has no great harmful action on plant tissue (p. 254–256).

NIEUWENBURG, C. J. VAN. (332)

VERSTIKKENDE EN DERGELIJKEOORLOGSGASSEN EN HUNNE BESTRIJDING. Chem. Weekbl. 19: 326–333. 1922.

War gases are described. The Germans produced a total of 6,130 tons of chloropicrin (p. 328).

NORRIS, J. F. (333)
THE MANUFACTURE OF WAR GASES IN GERMANY. Jour. Indus. and Engin. Chem. 11: 817–829. 1919.

Chloropicrin was made by adding picric acid little by little to an emulsion of bleaching powder, maintaining a temperature of about 30° C. by water cooling. The reaction vessels consisted of 6 units 8 feet in diameter and from 15 to 20 feet deep. They were lead lined and had coils on the side with a gate stirrer (p. 820–828).

ORTON, K. J. P., and McKIE, P. V. (334)
PREPARATION OF CHLOROPICRIN FROM PICRIC ACID AND TRINITROTOLUENES. Jour. Chem. Soc. [London] 119: 29–33. 1921.

If all the nitro groups of picric acid appear in the chloropicrin, the yield is 215 percent. Hofmann obtained a yield of 114 percent. A consistently better yield, reaching 200 percent, can be obtained by passing chlorine into a cooled suspension of picric acid (sodium picrate) in aqueous sodium carbonate. Picric acid is dissolved in a hot solution of 4 parts sodium carbonate (17 equivalents) in 50 parts of water. The thin paste is rapidly cooled to below 5° C. (to produce small crystals), and chlorine is added slowly or intermittently. Too rapid a current of chlorine wastes gas and produces chlorate. At 10° C. the solubility of chloropicrin in water is about 0.058 g per 100 cc. It rises somewhat with the temperature. The yield of chloropicrin from 2:4 dinitrophenol is only 50 percent of the maximum; from p-nitrophenol the yield is 33 to 34 percent of the maximum; from o-nitrophenol it is only 10 percent of the maximum. With trinitrotoluene, the proportions of 1 part nitro compound to 15 parts bleaching powder (active chlorine 29 percent) and 25 parts of water were found best. From TNT the yield (percentage of weight of material used) was 82 to 84 percent; from dinitrotoluene, 4 percent; and from s-trinitrobenzene, 53 percent.

——— and POPE, W. J. (335)
IMPROVEMENTS IN AND RELATING TO THE PRODUCTION OF CHLOROPICRIN. British Patent 142,878, issued June 10, 1920; applied for May 9, 1918.

The authors claim the process for the production of chloropicrin, which consists in treating picric acid or other suitable nitro derivatives of a phenol or a naphthol with a basic material and chlorine in the presence of water. An aqueous solution of sodium carbonate or sodium hydroxide is preferred.

PAILLOT, A. (336)
LES INSECTES NUISIBLES DES VERGERS & DE LA VIGNE. 366 p., illus. Paris. 1931.

The physical and chemical properties of chloropicrin and its preparation from picric acid and chloride of lime are described. At a dosage of 5 to 10 g per cubic meter, chloropicrin kills all kinds of insects in a few hours. Reference is made to Moore (*312*), Bertrand (*50*), and Gaumont (*177*) (p. 48–49).

PAPPENHEIMER, A. (337)
RAPPORT SUR LA PATHOLOGIE DES GAZ TOXIQUES DE GUERRE DANS LES FORCES EXPEDITIONNAIRES AMERICAINES. Arch. Med. Pharm. Mil. 73: 225–235. 1920.

Chloropicrin and diphenylchloroarsine are mentioned as irritants (p. 234).

PARFENT'EV, I. A. (338)
THE CONTROL OF STORAGE PESTS IN ELEVATORS. Defense des Plantes 2 (4–5): 202–205. 1925. [Abstract in Rev. Appl. Ent. (A) 14: 57–58. 1926.]

Chloropicrin was sprayed through a small opening into a wooden elevator of an old-fashioned type. From 30 to 60 minutes later (long enough for the evaporation of the liquid) the silo was loaded with grain through the same opening. For the fumigation of empty silos the proportion of 2 l of chloropicrin to 100 m³ of space was sufficient. When grain was about to be placed in these silos an extra 4 l was added for each load of grain

PARFENT'EV, I. A.—Continued.

THE CONTROL OF STORAGE PESTS IN ELEVATORS, ETC.—continued.

(about 36,000 pounds). After an exposure of 72 hours at a temperature of 41° to 48° F. to this concentration all weevils, mites, and eggs were killed. Though the grain retains the smell of the gas for some time, this disappears on milling, and no trace of scent or taste is perceptible in bread made from the flour. The germination of the seed, however, is slightly affected, although the fumigated grain has no toxic properties.

——— (339)

CHEMICAL METHODS OF INSECT CONTROL IN U.S.S.R. Fourth Internatl. Cong. Ent. Trans. 2: 836–847. 1929.

Granary weevils, both larvae and adults, were killed by 24 hours' exposure to the action of 0.1 volume percent chloropicrin in a hermetically closed vessel.

Rye and wheat are more sensitive to chloropicrin than oats and barley. The germinating power of wheat containing 12 percent moisture and exposed for 24 hours to 1.8 g of chloropicrin per cubic meter was 80 percent, whereas the corresponding figure for wheat containing 17.5 percent moisture was only 20 percent.

Feeding tests with young rats and beetle larvae (*Tenebrio molitor*) showed that chloropicrin-fumigated flour and chloropicrin-fumigated wheat retarded the growth of these animals.

"Chloropicrin is at present regarded in U.S.S.R. as a most valuable insecticide for the fumigation of empty granaries, stores, and also against household pests: Bugs, cockroaches, blackbeetles (chloropicrin has been tested for these purposes on a sufficiently large scale). The problem of chloropicrin-fumigation of grain, however, remains unsolved."

The diffusion rate of fumigants grows with the increase of concentration of the gas. Thus, with a sufficient concentration of chloropicrin the vapor can penetrate into the grain to a depth of 2 meters.

A special technic was worked out by the laboratory for disinfecting grain kept in the silos of elevators. The silos were filled with grain 10 meters deep. The insecticide used was chloropicrin. Before the silo was filled, chloropicrin was sprayed from a knapsack sprayer down the walls of the upper part of the silo, and left to evaporate till the required concentration of chloropicrin vapors was reached. After this, the silo was filled with grain, which thus fell through air saturated with the vapors of the insecticide. These experiments gave positive results.

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RESEARCHES IN INSECT TOXICOLOGY. Fourth Internatl. Cong. Ent. Trans. 2: 857–864. 1929.

Calendra [*Sitophilus*] *oryzae* is more susceptible to carbon disulphide, chloropicrin, hydrocyanic acid, sulphur dioxide, and pyridine than is *C. granaria*.

A table shows the minimum concentration of chloropicrin vapor in volume percent lethal to *Calendra granaria* L., larvae and beetles; C. [*Sitophilus*] *oryzae* L., beetles; *Sitodrepa panicea* L., larvae and beetles; *Tribolium confusum* Duv., larvae and beetles; *Tenebrio molitor* L., larvae, pupae and beetles; *Ephestia kuehniella* L., larvae; and *Tyroglyphus* [*Aleurobius*] *farinae*, eggs, larvae, and adults. These tests were made at room temperature and with 24 hours' exposure. With a 3-hour exposure a concentration of 0.7 percent chloropicrin is required to kill 100 percent of *Calendra granaria* L.

Adult beetles of *Calendra granaria* L. have proved to be more sensitive to chloropicrin and carbon disulphide vapor than those just emerged from the pupae and still have light brown elytra.

PARKER, T. (341)

CHLOROPICRIN PETROLEUM EMULSION AS AN APHICIDE. PRELIMINARY NOTE ON ITS USE. Fruit Grower 51: 1072. 1921.

An emulsion containing 5 percent chloropicrin when sprayed on larvae of *Trogoderma khapra* seemed to have no appreciable effect, but when the larvae were exposed to the vapor in an enclosed space, less than 1 percent was sufficient to prove fatal. An emulsion containing 5 percent chloropicrin, 50 percent petroleum oils, and 30 percent soap, when diluted

Parker, T.—Continued.

CHLOROPICRIN PETROLEUM EMULSION AS AN APHICIDE, ETC.—continued.

with water at the rate of 1 part to 80 parts of water, was very effective against aphids on broad beans and tomatoes; also against the *Aphis pruni* on plum trees and the *A. pomi* on apples. The plants and trees were sprayed at midday, but there was no sign whatever of scorching. This emulsion, 1 to 60, checked an attack of lesser bulb fly without damaging the onions. A plot of cabbages badly infested with *Brevicoryne* [*Aphis*] *brassicae* and just showing signs of an attack of cabbage maggot was similarly treated with excellent results. Chloropicrin, at the rate of 7 ounces per 1,000 cubic feet, was effective in killing whiteflies in a greenhouse, but exposure for 20 hours caused some scorching of tomato plants. Chloropicrin was handled by the operators without goggles and with no ill effects.

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THE SUPPRESSION OF INSECT PESTS AND FUNGOID DISEASES. 2. THE FUMIGATION AND DISINFECTION OF GLASSHOUSES. Bur. Bio-Technol., Leeds, Bul. 8: 244–248. 1923.

Red spider and the eggs of whitefly are unable to withstand the effects of "Alvesco Glasshouse Fumigant", one of the active ingredients of which is a chlorinated nitro compound (chloropicrin?). Caterpillars, scale, aphids, pill bug, and noxious weeds suffer a like fate. Chloropicrin is more effective in soil sterilization than ordinary cresylic acid (p. 246).

——— and Long, A. W. (343)

A LABORATORY NOTE ON THE CONTROL OF TROGODERMA KHAPRA. Bur. Bio-Technol., Leeds, Bul. 4, p. 102–104. 1921.

Chloropicrin when used at the rate of 10 ounces per 100 cubic feet killed 100 percent of the larvae exposed to it for 1,000 minutes. This test was made in a glass vessel of approximately 1-cubic foot capacity. Its effect on malt has not yet been determined.

Parman, D. C., Laake, E. W., Cook, F. C., and Roark, R. C. (344)

CHEMOTROPIC TESTS WITH THE SCREWWORM FLY. U.S. Dept. Agr. Bul. 1472, 32 p. 1927.

Chloropicrin mixed with lubricating oil in proportions of 1, 2, 4, and 10 percent was tested as a repellent against the screw worm (*Cochliomyia macellaria* Fab.). The 4- and 10-percent mixtures were effective in keeping the flies from baits of beef liver (p. 13, 25, 28, 29, 30, 31).

——— Laake, E. W., Bishopp, F. C., and Roark, R. C. (345)

TESTS OF BLOWFLY BAITS AND REPELLENTS DURING 1926. U.S. Dept. Agr. Tech. Bul. 80, 15 p., illus. 1928.

Results of tests with chloropicrin diluted with nine times its volume of mineral oil in repelling the screw worm (*Cochliomyia macellaria* Fab.) and *Lucillia* flies are recorded. Sixty-seven percent less of the former and 78 percent less of the latter visited the treated baits than visited the untreated baits (p. 9, 12).

Pascal, P. (346)

RECHERCHES MAGNETO-CHIMIQUES SUR LA STRUCTURE ATOMIQUE DES HALOGENES. Compt. Rend. Acad. Sci. [Paris] 152: 862–865. 1911.

The depreciation of the molecular diamagnetism and the experimental molecular susceptibility of chloropicrin are given (p. 863).

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UTILISATION DU CHAMP MAGNETIQUE COMME REACTIF DE LA CONSTITUTION. Bul. Soc. Chim. France 11: 159–163. 1912.

Data on the magnetic susceptibility of chloropicrin are given (p. 162).

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ETAT MOLECULAIRE, AUX BASSES TEMPERATURES, DU PEROXYDE D'AZOTE DISSOUS. Bul. Soc. Chim. France 33: 539–548. 1923.

The freezing point of binary mixtures of chloropicrin and nitrogen peroxide was determined. A mixture containing 8 percent of the peroxide forms a eutectic melting at −79.5° C. (p. 544–545).

Patein, G. (349)
LES GAZ TOXIQUES EMPLOYES PENDANT LA GUERRE. Jour. Pharm. et Chim. (7) 21: 19–28. 1920.

Chloropicrin was used in shell; also a mixture of 65 percent diphosgene and 35 percent chloropicrin. Chloropicrin is a lachrymatory and suffocating gas. Subjects slightly poisoned with this gas should be placed in a warm well-aired room in which water containing eucalyptus tincture is boiled. Vomiting is induced with ipecac; hot tea is given, also oxygen. In severe cases, caffeine is injected and from 5 to 10 minutes later the patient is bled (300 to 500 g).

Perkin, W. H. (350)
THE MAGNETIC ROTATORY POWER OF NITROGEN COMPOUNDS, ALSO OF HYDROCHLORIC, HYDROBROMIC, AND HYDRIODIC ACIDS, AND OF SOME OF THE SALTS OF AMMONIA AND THE COMPOUND AMMONIAS. Jour. Chem. Soc. [London] 55: 680–749. 1889.

Chloropicrin dried over phosphorus pentoxide and then distilled from anhydrous potassium carbonate boiled constantly at 112° C. (corrected). The density determination gave the following specific gravity data: 4/4, 1.6855; 10/10, 1.6748; 15/15, 1.6670; 20/20, 1.6594; and 25/25, 1.6528. The average specific magnetic rotation at a temperature of 12.7° was 0.9843; the molecular rotation was 5.384.

Perrot, E. (351)
INSECTICIDES ET VERMICIDES, LE PYRETHRE ET SES APPLICATIONS. Bul. Soc. Encour. Indust. Natl. [Paris] 130 (12): 709–722. 1931.

Chloropicrin is included in a list of fumigants (p. 713).

Petrov., A. D., Reckhardt, A N., and Isachenko, V. B. (352)
THE USE OF CHLOROPICRIN FOR THE FUMIGATION OF WAREHOUSES AND DWELLINGS. Izv. Prickl. Ent. 4 (1): 131–150. 1929. [In Russian, with a summary in German. Abstract in Rev. Appl. Ent. (A) 18: 129. 1930.]

An account is given of a number of successful experiments with chloropicrin, chiefly against *Anobium punctatum* DeG. and *Tineola bisselliella* Humm. At 10° C. (50° F.) larvae of the former in pieces of willow basket were killed in 24 hours with 8 ounces to 1,000 cubic feet. With 9 and 1½ ounces, larvae of *T. bisselliella* in their cocoons were killed in 2½ and 72 hours, respectively. At the same concentration as that used in the first experiment, but with a slightly longer exposure, the fumigant easily penetrated planks about an inch thick, killing all the Anobiid larvae. In thicker planks, infested at a depth of 2 inches, the dosage and exposure had to be considerably increased unless vacuum fumigation was employed. Folded thick fabrics and furs fumigated with 20 ounces to 1,000 cubic feet were penetrated under ordinary atmospheric pressure. Fabrics absorb chloropicrin more readily than carbon disulphide and therefore require longer airing than when the latter is used. Absorption by wood is highest in pine, and depends on the way in which it has been dried, polished, etc. The gas did not affect the durability or color of fabrics or furs and did not tarnish metals or injure paper. It was found to kill fungi and bacteria, whereas carbon disulphide did not. It is also cheaper and safer to use than carbon disulphide or hydrocyanic acid. A low concentration of the gas and a long exposure are preferable to a high concentration for a short time.

——— **and Savel'ev, A. O.** (353)
DECOMPOSITION OF CHLOROPICRIN ON HEATING IN CONTACT WITH METALS. Zhur. Prikladnoi Khim. 2: 629–632. 1929. [Abstract in Chem. Abs. 24: 775. 1930.]

Chloropicrin was heated in contact with copper, brass, tin, platinum, zinc, aluminum, thallium, lead, and iron. Temperature is of primary importance because at 100° decomposition is slight, whereas at 112.7° (boiling point of chloropicrin) its rate increases 10 times. The rate of decomposition is practically proportional to time. Metals have little catalytic action, and metallic containers are permissible in commercial practice. Heating to 100° is also feasible. The catalytic effect of iron and lead is the least, whereas that of brass is the greatest.

PICCININI, G. M. (354)
I GAS ASFISSIANTI. Rass. Clin. Terap. Sci. Affini. 19: 154–174. 1920.

Chloropicrin is listed as a lachrymatory gas (p. 157). A bibliography of 12 titles, through August 1918, is given.

PICTET, A., and KHOTINSKY, E. (355)
UBER ACETYLNITRAT. Ber. Deut. Chem. Gesell. 40: 1163–1166. 1907.

Chloroform heated with acetyl nitrate yields chloropicrin (p. 1165).

PIEDALLU, A. (356)
LA DESTRUCTION DES CHARANCONS ET AUTRES PARASITES DES GRAINS ET LEGUMES SECS. Ann. Sci. Agron. Franç. et Étrang. 39 (6): 353–365. 1922.

The method of fumigating large quantities of wheat with chloropicrin is described in detail. A dosage of 10 to 30 g per cubic meter is recommended. Wheat freed of all traces of chloropicrin has given normal results in germination, milling, and baking tests.

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LA DESTRUCTION DES PARASITES DANS LES GRAINS. Bul. Soc. Natl. Acclim. France. 69 (4): 71. 1922.

A brief report on fumigation of cereals with chloropicrin given to the Societe Nationale d'Acclimatation de France at its meeting on January 23, 1922. The results of this work are published in Revue d'Histoire Naturelle Appliquée.

——— (358)
EXPERIENCES SUR LA DESTRUCTION DES INSECTES NUISIBLES AUX GRAINS ET AUX LEGUMES SECS. Ann. Epiphyties 8: 309–311. 1922.

All weevils (Charancons) in a bag of oats were killed by the application of carbon tetrachloride in a tight enclosure at the rate of 200 g per cubic meter, allowing 48 hours' exposure. Chloropicrin gives excellent results when used at the rate of 10 g per cubic meter. At Saint-Cyr the author has fumigated with chloropicrin 300 quintaux (30,000 kg) of oats and 800 quintaux (80,000 kg) of beans. The parasites included Charancons, Ephestias, and Souris.

——— (359)
SUR LA DESTRUCTION EN GRAND DES PARASITES DES GRAINS. Compt. Rend. Acad. Agr. France 9: 364–368. 1923.

Piedallu reports tests in which large quantities of wheat, oats, beans, and lentils were fumigated successfully with chloropicrin in a tent, in small and large warehouses, and in silos. Ten liters of chloropicrin were used in a 150-ton silo. All insects were destroyed after exposure for 3 weeks. Flour made from wheat fumigated in this silo was not objected to, and baked in a normal manner. This wheat after fumigation showed from 92 to 98 percent germination. Wheat placed in a flask and treated with chloropicrin at the rate of 650 g per cubic meter (10 to 30 g are sufficient) showed 75 to 78 percent germination after 3 weeks' contact. In these tests it is essential to allow the wheat to become thoroughly aerated; otherwise the germination may fall to 56 or even to 48 percent. Carbon tetrachloride gives good results in a well-closed place when used at the rate of 200 g per cubic meter.

——— (360)
DESTRUCTION DES PARASITES DANS LES APPROVISIONNEMENTS DES CEREALES. Chim. et Indus. [Paris], numero special, May 1924, p. 740–742. 1924.

The author has treated 35,000 quintals [1 quintal=100 kg or 220.46 pounds] of wheat, more than 50,000 quintals of oats, and 1,000 quintals of dry legumes with chloropicrin. 20 liters of chloropicrin to 1,000 quintals of wheat in a small warehouse was used. The use of an A. R. S. mask or a Tissot mask is indispensable. Wheat treated with chloropicrin at the rate of 650 g per cubic meter (10 to 30 g is sufficient), the exposure being 3 weeks, showed 75 to 78 percent germination. The grain must be thoroughly aerated; a trace of chloropicrin causes the germination to fall to 56 or even to 48 percent. Carbon tetrachloride and paradichlorobenzene have also been used by Piedallu.

PIEDALLU, A.—Continued. (361)

DESTRUCTION DES PARASITES DANS LES APPROVISIONNEMENTS DE CEREALES. Jour. Agr. Prat. 45: 113–117. 1926.

Carbon tetrachloride may be used at the rate of 200 grams per cubic meter. Paradichlorobenzene kills weevils in grain but leaves an objectionable odor. Chloropicrin has given the best results in grain fumigation. It is essential to fumigate in an enclosed space as tight as possible. A storehouse of 8,750 m^3, containing 27,000 quintals (2,700,000 kg) of wheat, and two storehouses of 7,500 and 15,000 m^3, containing 150,000 quintaux (15,000,000 kg) of oats were successfully fumigated with chloropicrin. Chloropicrin may be used under a tent to treat sacks of grain, or in silos (10 l of chloropicrin to a 150-ton silo). Thirty-five thousand quintaux (3,500,000 kg) of wheat fumigated with chloropicrin were consumed as bread without provoking criticism. In fumigating with chloropicrin the use of an A. R. S. gas mask is indispensable. Wheat thoroughly aerated after chloropicrin fumigation is not injured for breadmaking or in germinating quality. Chloropicrin fumigation is recommended if the proper precautions are taken and if the space is sufficiently tight (*204*).

——— and BALACHOWSKY, A. (362)

UTILISATION DE LA CHLOROPICRINE CONTRE DES COCHENILLES NUISIBLES AUX ORANGERS OU AUX DATTIERS. Bul. Agr. Algérie, Tunisie, Maroc 34 (2) 181–183. 1928. Also in Compt. Rend. Acad. Sci. [Paris] 187: 671–673. 1928.

Experiments are reported on the fumigation of orange trees, date trees, and *Strelitzia augusta* against harmful cochineal insects with chloropicrin. The scales used are *Chrysomphalus aonidum* L., *C. dictyospermi* Morg., *Parlatoria pergandii* Conest., *P. blanchardi* Targ., *Aspidiotus lataniae* Sig., *Diaspis zamiae* Morg., and *Pseudococcus aonidum* L. The burning effect on the plant is given. Chloropicrin, dispersed by means of heat, kills the principal harmful cochineal insects at concentrations of 15 and 20 g per cubic meter in 45 minutes to 1 hour. Since chloropicrin vapors attack the tender shoots and flowers, it is recommended that the treatment be used after the harvest and before the flowering.

PILLSBURY, H. C. (363)

X-RAY FINDINGS IN THE CHRONIC GAS CASES. Amer. Jour. Roentgenol. 8: 192–195. 1921.

Chlorine, chloropicrin, and especially phosgene leave behind them a chronic change in the lungs. With chloropicrin the most notable effect is seen on the medium and small bronchi. X-ray findings of gassed cases are described.

PIUTTI, A. (364)

SUR L'ACTION DE LA CHLOROPICRINE SUR LES PARASITES DU BLE ET SUR LES RATS. Compt. Rend. Acad. Sci. [Paris] 170: 854–856. 1920.

Chloropicrin, when used at the rate of 20 cc per cubic meter of space, whether or not occupied by wheat, at 15° to 20° C., and with an exposure of about 1 week, has given excellent results against *Calendra granaria*, *Tenebroides mauritanicus*, *Laemophloeus ferrugineus*, *Sitotroga cerealella*, *Tinea granella*, and *Plodia interpunctella*. Rats in two ships were destroyed with chloropicrin at the rate of 1.5 kg for 1,875 m^3 of space after exposure for 2½ hours, the fleas infesting them being killed in even less time. Neither the flour nor the bread made from such grain deteriorates in any degree, so far as its nutritive value is concerned, although the grain loses about 30 percent of its germinating power.

——— (365)

AZIONE DELLA LUCE SOPRA LE SOLUZIONI ALCOOLICHE ED ACETONICHE DI CLOROPICRINA. Gaz. Chim. Ital. 51 (1): 145–146. 1921.

Freshly distilled chloropicrin is a colorless liquid; boiling point, 111.91° C. under 752 mm pressure; density at 0°, 1.69247. It becomes yellow in diffused light and in sunlight assumes the color of nitrous vapors. The solutions of chloropicrin in ethyl alcohol, methyl alcohol, benzene, turpentine, acetic acid, etc., remain unchanged in the dark, but exposed to light all except those in the alcohols become colored. The solutions in alcohols after 1 day separate into two layers, and white crystals of

PIUTTI, A.—Continued. (365)

AZIONE DELLA LUCE SOPRA LE SOLUZIONI ALCOOLICHE ED ACETONICHE DI CLOROPICRINA—continued.

ammonium chloride separate at the bottom. Acetone solutions are somewhat colored and do not separate in two layers, but deposit ammonium chloride. Evidently the alcohols reduce the NO_2 to NH_2 and then NH_3. The alcohol or acetone solution may be boiled in the dark and remains unchanged.

——— (366)

L'AZIONE DELLA CHLOROPICRINA SULLE CRISALIDI DEL BACO DA SETA. Rend. Accad. Sci. Fis e Mat. Napoli 34 (3) : 106-111. 1927.

Killing silk worm pupae by 1 hour's exposure to 0.01 g chloropicrin per liter instead of by heat represents a saving in time and equipment and eliminates the risk of heat injury to the cocoon. There is no harmful effect on the thread. The yield in degummed thread is 9.8 percent higher than by the old process. The pupae should be used for the manufacture of fatty oils in preference to fertilizer. The poisoned pupae yield on extraction 1.5 to 2 percent more oil, from which stearic acid separates on standing. The latter is perhaps formed by the sudden poisoning.

——— and BADOLATO, P. (367)

AZIONE DELLA LUCE SOPRA MISCELE DI CHLOROPICRINA E DIVERSE SOSTANZE ORGANICHE. Atti Cong. Naz. Chim. pura Appl., p. 437–438. 1923.

In the presence of certain compounds the decomposition of chloropicrin by light is accompanied by oxidation, chlorination, or nitration of the other compound. Action of light on solutions of chloropicrin in acetic acid, diethyl succinate, methyl salicylate, toluene, and naphthalene is described.

——— and BADOLATO, P. (368)

AZIONE DELLA LUCE SOPRA SOLUZIONI DI ALCUNE SOSTANZE ORGANICHE NELLA CHLOROPICRINA. Rend. Accad. Sci. Fis e Mat. Napoli (5) 33: 475–479. 1924.

Light decomposes solutions of acetic acid, diethyl succinate, methyl salicylate, toluene, naphthalene, phenol, pseudocumene, o- m- and p-xylene with chloropicrin. Oxidation, chlorination, or nitration accompanies the decomposition.

——— and BERNARDINI, L. (369)

APPLICAZIONI DEL TRICLORONITROMETANO CCl_3NO_2 (CLOROPICRINA) ALLA DESCRIZIONE DI FORME VEGETALI ED ANIMALI DANNOSE ALL'AGRICOLTURA, ALL'INDUSTRIA ED ALL'IGIENE. Italian Patent 158,214. 1917.

This patent claims the use of chloropicrin, in the liquid or gaseous state, alone or mixed with other liquid or gas not only for the disinfection of cereals but also for the conservation of fruit and all edible substances which can be attacked and damaged by animal and vegetable parasites. It also claims the application of chloropicrin for killing rats. The application of chloropicrin, whether in the liquid or vapor state, for the destruction of all forms of life, animal and vegetable, infesting vineyards, fruits, olive groves, and plants in cultivated places, flowers, cuttings, herbs, etc., is claimed.

——— and BERNARDINI, L. (370)

SOPRA L'AZIONE DELLA CLOROPICRINA (TRICLORONITROMETANO) SUI PARASSITI DEL GRANO. Rend. Accad. Sci. Fis e Mat. Napoli (3) 23: 51–53. 1917.

Chloropicrin is superior to carbon disulphide, carbon tetrachloride, sulphur dioxide, and hydrocyanic acid for fumigating cereals. One twentieth cc (85 mg) of chloropicrin per kilogram of cereal kills parasites in 20 hours. Tests were made with *Calendra granaria*, *Tenebrioides mauritanicus*, *Laemophloeus ferrugineus*, *Sitotroga cerealella*, *Tinea granella*, and *Plodia interpunctella*.

——— and BERNARDINI, L. (371)

SULLA DERATTIZZAZIONE NEI TRANSPORTI NAVALI MEDIANTE LA CLOROPICRINA. Rend. Accad. Sci. Fis e Mat. Napoli (3) 24: 16–19. 1918.

Describes the killing of rats on two ships. On one ship 200 cc of chloropicrin was used for a space of 800 m^3, the exposure being 10 hours. On the other ship 1 kg was used for a space of 1.075 m^3.

Piutti, A., and Mango, A. (372)

SULL' IMPIEGO DELLA CLOROPICRINA (TRICHLORONITROMETANO) NELLA DISINFEZIONE DEI CEREALI. Gior. Chim. Indus. et Appl. 2: 677–682. 1920; Rend. Accad. Sci. Fis e Mat. Napoli (3) 26: 77–88. 1920.

Chloropicrin is an efficacious parasiticide, the proper dose being 20 cc per cubic meter of surrounding space, whether occupied by cereal or not. The action should proceed for not less than 8 days where large quantities of cereal are to be fumigated. Chloropicrin does not injure corn in any way, nor does it influence the leavening of bread with natural yeast. Germination power is diminished about one third. Chloropicrin can be detected in concentrations of only 1 in 300 million. The insects used in these tests were the granary weevil (*Calendra granaria* L.) and *Tenebroides mauritanicus* L.

——— and Mazza, F. P. (373)

AZIONE DEI RAGGI ULTRAVIOLETTI SULLA CLOROPICRINA. Rend. Accad. Sci. Fis e Mat. Napoli (3) 32: 97–102. 1926: Also in Gaz. Chim. Ital. 57: 610–614. 1927.

Chloropicrin decomposes under the action of ultraviolet light. The products are at first nitrosyl chloride and phosgene, but the latter splits into carbon monoxide and chlorine. It is the great activity of the products of decomposition which accounts for the action of chloropicrin on organic substances in light.

Pohl, T., and Tesch, B. (374)

ADMIXTURE OF IRRITANTS IN HYDROCYANIC GAS DISINFECTION WITH ESPECIAL REFERENCE TO THE USE OF CHLOROPICRIN AS A DANGER INDICATOR IN ZYKLON C. Desinfektion 11: 88–90. 1926. [Abstract in Chem. Abs. 20: 3765. 1926.]

Methyl chloroformate is not sufficiently stable to serve as a danger indicator in hydrocyanic acid gas fumigation. A mixture of 10 parts by weight of hydrocyanic, 1 part chloropicrin and 0.3 part ethyl monobromacetate is recommended as safe for the disinfection of apartments without the necessity of vacating the adjoining apartments, provided the usual precautions are observed and the wall material is sufficiently nonporous to warrant a safe hydrocyanic disinfection.

Pospelov, V. P., Sal'dau, P. Y., Petrov, A. D. and Isachenko, V. B. (375)

EXPERIMENTAL DISINFECTION OF GRAIN AND FLOUR WITH CHLOROPICRIN AND OTHER VOLATILE SUBSTANCES. Bur. Appl. Ent. Rpt. 3: 36–54. 1927. [Abstract in Rev. Appl. Ent. (A) 16: 172. 1928.]

For the control of *Callosobruchus* (*Pachymerus*) *chinensis* L. the toxicity of ethyl acetate with carbon tetrachloride is similar to that of carbon bisulphide, but the mixture is less effective against *Calendra granaria* L. and *Tyroglyphus* [*Aleurobius*] *farinae* DeG. It is more expensive than carbon bisulphide and not practical for general use. Chloropicrin is 8 to 10 times as effective as carbon bisulphide against all three species, but as it penetrates very slowly through stacked grain, if placed in containers, it appears best to distribute it throughout the grain by spraying, etc. It has no effect on the germination of oats, but it reduces that of wheat and rye. The practical application of chloropicrin, which alone is described in a second paper, was tested in rooms containing packets of pulses infested by *C. chinensis*. The chloropicrin was poured into a number of containers, the depth of the liquid being about 0.1 inch. Though one half ounce to each 100 cubic feet proved effective under laboratory conditions, double this concentration was used on account of the crowded condition of the rooms. In 96 hours at 14° C. (47.2° F.) all the chloropicrin had evaporated, and the Bruchids of all stages were dead. By the end of the day the room could be entered without any protection against the gas. The germination of the seed had apparently not been affected.

Prandtl, W., and Sennewald, K. (376)

ÜBER DAS TRICHLOR-NITROSO-METHAN, DAS DICHLOR-FORMOXIM (PHOSGEN-OXIM) UND EINIGE IHRER DERIVATE. Ber. Deut. Chem. Gesell. (B) 62: 1754–1768. 1929.

Trichloronitrosomethane decomposes, slowly on standing and more rapidly on heating, into nitrosyl chloride, a little nitric oxide, chloropicrin, and [trichloromethyl]-[dichloromethylene] amine Cl_3CNCCl_2. At room

PRANDTI, W., and SENNEWALD, K.—Continued.

ÜBER DAS TRICHLOR-NITROSO-METHAN, DAS DICHLOR-FORMOXIM (PHOSGEN-OXIM) UND EINIGE IHRER DERIVATE—continued.

temperature and even at its boiling point trichloronitrosomethane reacts only slowly with oxygen, but a mixture of its vapors and oxygen passed through a tube at 120° deflagrates with formation of hexachloroethane. nitrogen peroxide, and chloropicrin.

PRIBRAN, R., AND HANDL, A. (377)

ÜBER DIE SPECIFISCHE ZÄHIGKEIT DER FLÜSSIGKEITEN UND IHRE BEZIEHUNG ZUR CHEMISCHEN CONSTITUTION. Sitzber. Akad. Wiss. Wien, Math. Naturw. Kl. 80 (2) : 17–57. 1879.

The viscosity of chloropicrin is studied (p. 24, 57).

PUSSARD, R. (378)

SUR LE NIPTUS HOLOLEUCUS FALD. Compt. Rend. Soc. Biol. [Paris] 99 (26) : 826–827. 1928.

Despite the resistance of the adult of *Niptus hololeucus* Fald. to an asphyxiating gas such as carbon disulphide and hydrocyanic acid, total destruction of adults and larvae. some placed under three thicknesses of sacks and others in a box under 10 to 15 cm of sawdust, is obtained with a dose of chloropicrin of 5 cc per cubic meter of space.

——— (379)

SUR LA DESTRUCTION DU COLÉOPTÈRE NIPTUS HOLOLEUCUS FALD. PULLULANT DANS UNE VILLA AUX ENVIRONS DE LYON. Rev. Path. Veg. Ent. Agr. 16: 29–33. 1929.

Fumigation with chloropicrin at a temperature of 19° C. and with an exposure of 24 hours at a dosage of 8 cc (13.32 g) per cubic meter killed young and adult cockroaches (*Blatta* [*Periplaneta*] *orientalis*), bedbugs (*Cimex lectularius*), and the eggs, larvae, and adults of *Niptus hololeucus* (p. 33).

QUAYLE, H. J. (380)

DEVELOPMENTS IN THE FUMIGATION OF CITRUS TREES. Fourth Internatl. Cong. Ent. Trans. 2: 155–161. 1929.

"I have been experimenting recently with other gases including carbon tetrachloride, ethyl acetate, ethylene dichloride, ethylene oxide, vinyl chloride, nicotine, carbon disulphide, and chloropicrin, but none of these approaches hydrocyanic for citrus fumigation from the standpoints of insecticidal value and of tree tolerance."

R., H. (381)

COMMENT DETRUIRE LES PARASITES DES GRAINS. Rev. Vitic. 59 (1519) : 106. 1923.

This is an abstract of the article by Piedallu (*359*).

RANDIER, P. (382)

LA CHLOROPICRINE SES PROPRIETES PHYSÍQUES ET CHIMIQUES, SA TOXICITE VIS-A-VIS DES ETRES VIVANTS SES APPLICATIONS CHLOROPICRINATION DU NAVIRE ATELIER RUSSE "KRONSTADT." Arch. Med. Pharm. Navales 112: 56–78. 1922.

Reviews the work of Bertrand, Piutti, and others. The destruction of rats on a 16,400-ton boat is described. The chloropicrin (295 kg) cost 5 francs per kilogram. It was syphoned from four reservoirs in different parts of the vessels, through rubber tubes. Rats and fleas were killed. There was no action on fabrics or metals, although the rubber tubes used in distributing the chloropicrin were softened. Experiments made in the hospital at Sidi-Abdallah showed that cultures of paratyphoid bacillus. the bacillus of Yersin, and the bacillus of Eberth failed to grow after having been exposed to chloropicrin vapor of the same concentration as that used in the ship. The pest bacillus in animals was not affected, however. Although provided with A.R.S. masks and Tissot apparatus, the operators suffered severely from the chloropicrin.

Randier, P.—Continued. (383)
QUELQUES REFLEXIONS AU SUJET DE LA CHLOROPICRINATION DU "KRONSTADT." Jour. Med. Bordeaux 96: 663–665. 1924.

The only serious difficulty in fumigating ships with chloropicrin is the removal of the vapors. Details of the fumigation of the Kronstadt with chloropicrin at the rate of 12 g per cubic meter are given. It is believed that a lower concentration would suffice, and would render subsequent ventilation of the ship much easier.

Rankin, G. A. (384)
CHEMICAL WARFARE AGENTS AND THEIR RELATION TO COMMERCIAL CHEMICALS. Chem. Warfare 12 (5): 5–11. 1926.

A description of the commercial uses of chemical warfare agents and of the commercial uses of the raw materials required to make them is given. Chloropicrin is stated to be an effective insecticide (p. 8).

Rasch, W. (385)
WAS IST BEI BLAUSAUREDURCHGASUNGEN ZU BEACHTEN UND WIE WEIT KANN EINE BLAUSAUREDURCHGASUNG DURCH ANDERE MASSNAHMEN ERSETZT WERDEN. [Reprint from Der Müller. No date. Abstract in Rev. Appl. Ent. (A) 11: 15. 1923.]

For fumigating flour mills chloropicrin is useful for work on a small scale, but it attacks metals.

Raschig, F. (386)
REDUCTION DES CHLORPIKRINS UND DES DINITRODICHLORMETHANS. Ber. Deut. Chem. Gesell. 18: 3326–3328. 1885.

Reduction of chloropicrin with stannous chloride and hydrochloric acid gives trichloromethylamine and its decomposition products, cyanogen chloride, and hydrochloric acid.

Rath, and **Maier-Bode, H.** (387)
VERGASUNGSMITTEL IN DER SCHÄDLINGSBEKÄMPFUNG. Ztschr. Angew. Chem. 44 (22): 415–417. 1931.

Brief descriptions are given of sulphur dioxide, carbon disulphide, carbon tetrachloride, hydrocyanic acid, chloropicrin, paradichlorobenzene, naphthalene, hexachloroethane, ethylene oxide, nicotine, pyrethrum, formaldehyde, and acetylene as insecticidal fumigants.

Rathke, B. (388)
UEBER DIE EINWIRKUNG VON SCHWEFLIGSAUREM KALI AUF CCl_3 ENTHALTENDE KÖRPER. Ann. Chem. 161: 149–171. 1872.

Digested with a somewhat concentrated solution of acid potassium sulphite, chloropicrin forms $CHNO_2(SO_3K)_2$ (p. 153).

Ray, P. C., and **Das, R.** (389)
CHLOROPICRIN AS A REAGENT FOR THE DIAGNOSIS OF MERCAPTANS AND POTENTIAL MERCAPTANS. Jour. Chem. Soc. [London] 121: 323–328. 1922.

Seventeen typical thio-compounds have been subjected to the action of chloropicrin. Of these, five are known to be real mercaptans, and the rest are potential ones. In not a single instance has a separation of sulphur been found in the case of real mercaptans, whereas sulphur is either partly or completely eliminated from the potential mercaptans. Chloropicrin may therefore be safely used as a reagent for the diagnosis of mercaptans and potential mercaptans.

——— **Guha, P. C.**, and **Das, R.** (390)
REACTION OF THE POTASSIUM SALTS OF 2-THIOL 5-THIO-4-PHENYL-4: 5-DIHYDRO-1: 3: 4-THIODIAZOLE AND 2: 5-DITHIOL-1: 3: 4-THIODIAZOLE WITH HALOGENATED ORGANIC COMPOUNDS. Jour. Chem. Soc. [London] 115: 1308–1312. 1919.

Chloropicrin reacts more readily than chloroform with mercaptides, the reaction being as follows: $3RK+NO_2CCl_3=NO_2CR_3+3KCl$. A compound $C_{25}H_{15}O_2N_7S_9$ (melting point 128–9) was obtained from chloropicrin and the potassium salt of the first of the foregoing compounds; a compound $C_8ON_6S_9$ (melting point 166–8) was obtained from chloropicrin and the potassium salt of the second compound.

RAYNAUD, L. (391)
SUR UN NOUVEL APPAREIL PERMETTANT D'EMPLOYER LA CHLOROPICRINE SANS MASQUE ET SANS DANGER, POUR LA DESTRUCTION DES PARASITES DES HABITATIONS. Off. Internatl. Hyg. Pub. [Paris], Bul. Mens. 22: 763–765. 1930.

This apparatus consists of a bottle mounted on a tiltable platform. By means of a string the platform is tilted and the chloropicrin in the bottle splashed out on the floor. A dosage of 8 to 10 g per cubic meter is employed.

RECTOR, T. M. (392)
THE ABSORPTION OF WAR GASES BY RUBBER AND RUBBERIZED FABRIC. Indus. and Engin. Chem. 15: 1132–1134. 1923.

Chloropicrin when present in quantities exceeding 2 parts per million in air causes involuntary closing of the average eye. A measurable interval of time elapses between exposure to the gas and the closing of the eye; this time interval varies with the concentration. This variation can be used to determine the concentration of chloropicrin in the air between 1 and 30 parts per million. Phosgene, chloropicrin, and mustard gas are highly soluble in rubber. Chloropicrin is absorbed at a faster rate than phosgene, and is also given up at a faster rate.

REDDISH, G. F. (393)
REPORT ON THE GERMICIDAL ACTION OF CHLOROPICRIN. Private communication to the compiler, March 2, 1926.

When tested by the wet filter paper method, chloropicrin kills both *B. typhosus* and *M. aureus* in 15 minutes.

REMY, P. (394)
DE L'ACTION DES VAPEURS DE CHLOROPICRINE SUR L'ARGAS REFLEXUS FABR. Compt. Rend Acad. Sci. [Paris] 172: 1619–1621. 1921.

An exposure of 13 hours in an atmosphere containing 10 mg chloropicrin per liter, at 15° to 18° C., causes paralysis of all individuals; 80 mg per liter causes paralysis in 3 hours; intermediate quantities act in intermediate periods of time. This parasite is commonly known as the pigeon tick. Masks should be worn while handling the gas. The eggs hatch in 8 to 15 days, requiring a second application of chloropicrin about 1 month after the first.

RENNIE, J. (395)
ACARINE DISEASE IN HIVE BEES; ITS CAUSE, NATURE, AND CONTROL. North Scot. Col. Agr. Bul. 33, 34 p. 1927.

A detailed account of acarine disease in bees caused by *Acarapis woodi* Rennie is given. A preparation made of 1 part of chloropicrin, 1 part of camphor, and 12 parts of methyl salicylate acts as a check, killing the parasitic mites wherever it reaches them. The affected bees die out and are replaced by degrees by healthy ones. The preparation will also prevent the beginning of disease in the hive and is a safeguard against reinfections. Frequent small doses at short intervals are safer than large ones at long intervals. Large doses disturb the bees. It should not be used during the honey flow. The suggested dose is approximately 0.1 cc per hive used at intervals of 2 days (increased perhaps to a daily dose) for some weeks. It is applied by means of a pipette on some porous material, such as pumice, in the hive, after which the hive is immediately closed (p. 31–33).

RICHARDS, W. L. (396)
NOTES ON THE FIELD TREATMENT OF CHEMICAL WARFARE CASUALTIES. Chem. Warfare 14 (4): 317–322. 1928.

The method of handling patients exposed to chloropicrin and other war gases is described (p. 320).

RIDLON, J. R. (397)
SOME ASPECTS OF SHIP FUMIGATION. Public Health Rpts. [U.S.] 46: 1572–1578. 1931.

A mixture of hydrogen cyanide with 20 percent cyanogen chloride has a greater lachrymatory effect than a mixture of hydrogen cyanide with

RIDLON, J. R.—Continued.

SOME ASPECTS OF SHIP FUMIGATION—continued.

5 percent chloropicrin. One should always use test animals to see whether a ship's hold is free of cyanide gas after using chloropicrin as a warning gas. Liquid hydrogen cyanide with 5 percent chloropicrin is cheaper than the mixture of hydrogen cyanide with 20 percent cyanogen chloride and is also more deadly to roaches and presumably also to rats (p. 1575).

——— (398)

EXPERIMENTS WITH CERTAIN FUMIGANTS USED FOR THE DESTRUCTION OF COCKROACHES. Pub. Health Rpts. [U.S.] 46: 1623–1636. 1931.

Chloropicrin was tested in the following combinations: Liquid hydrocyanic acid containing 10 percent chloropicrin, Zyklon-B with 5 percent chloropicrin, and liquid hydrocyanic acid containing 5 percent chloropicrin. Exposure to liquid hydrocyanic acid with 10 percent chloropicrin in the proportion of 60 g or less per 1,000 cubic feet was not thoroughly effective in killing all roaches. Eggs hatched after exposure to 30 g per 1,000 cubic feet. Liquid hydrocyanic acid with 5 percent chloropicrin was effective in killing roaches in 18 out of 20 tests in which 60 g per 1,000 cubic feet for 2 hours was used. This amount was effective in 18 tests when the exposure was for 4 hours.

RIEHM, E. (399)

PRÜFUNG VON PFLANZENSCHUTSMITTELN IN DEN JAHREN 1921–22. Mitt. Biol. Reichansts. Land u. Forstw. 24: 3–104. Berlin. 1923.

A review of recent work with chloropicrin based on publications of the following: Dingler (*123*), Guerin and Lormand (*198*), Miege (*305*), Neifert and Garrison (*328*), Piutti (*364*), Schindler and Trouvelot (*425*), Spencer (*449*), Thiem (*469*), Vayssiere (*501*), and Wille (*521*, *522*) (p. 16–18).

——— (400)

PRÜFUNG VON PFLANZENSCHUTSMITTELN IM JAHRE 1923. Mitt. Biol. Reichsanst. Land u. Forstw. 26: 3–88. Berlin. 1925.

A review of the work of Faes (*138*) and Feytaud and Staehelin (*151*) with chloropicrin (p. 15).

RINGELMANN. (401)

LA LUTTE CONTRE LES CAMPAGNOLS DANS LES REGIONS LIBEREES. Compt. Rend. Acad. Agr. France 5: 874–876. 1919.

A discussion of means of combating field mice, among which is the use of chloropicrin. It may be sprayed on the soil, sprinkled or introduced into the soil.

ROARK, R. C. (402)

INSECTICIDE OR FUMIGANT AND FUMIGATING METHOD. Brit. Patent 234,456, issued April 22, 1926; applied for March 30, 1925.

Essentially the same as U.S. Patent 1,649,254 (*403*) which covers the use of ethyl acetate as a fumigant. Chloropicrin, which has been proposed to fumigate granary weevils, requires that workmen wear gas masks. It is unavailable commercially.

——— (403)

FUMIGANT. U.S. Patent 1,649,254, issued November 15, 1927; applied for August 4, 1924.

In the description of this patent, which covers the use of ethyl acetate as an insecticide, the disadvantages of chloropicrin as a grain fumigant are stated to be its lachrymatory effect, low vapor pressure at ordinary temperatures, and nonavailability commercially.

——— (404)

IMPORTANCE OF PATENT LITERATURE TO ECONOMIC ENTOMOLOGISTS. Jour. Econ. Ent. 20: 640–641. 1927.

In emphasizing the importance of the information in patent literature it is pointed out that chloropicrin as an insecticide was patented in 1907 in England by Howorth (*229*), but 10 years elapsed before it was rediscovered by an American entomologist, Moore (*311*).

ROARK, R. C.—Continued. (405)
MODERN METHODS OF DISINFECTING AND FUMIGATING. Natl. Safety News, p. 23–24, January 1928.

Chloropicrin is referred to as a recently introduced fumigant which should be used at the rate of not less than 1 pound per 1,000 cubic feet of inclosed space.

——— (406)
ECONOMIC ASPECTS OF THE USE OF INSECTICIDES. Chem. Markets 22: 303–304. 1928.

Chloropicrin is included in a list of insecticides for which no production figures are available (p. 303).

——— (407)
CHEMISTS IN FRONT RANKS IN WARFARE ON HARMFUL INSECTS. U.S. Dept. Agr. Yearbook 1927: 177–179. 1928.

Chloropicrin is mentioned as having been patented as an insecticide by an Austrian chemist several years before it came to the attention of entomologists.

——— (408)
UNITED STATES INSECTICIDES STATISTICS FOR 1928. Jour. Econ. Ent. 22: 699, 701. 1929.

Figures on the production of chloropicrin are not available.

——— (409)
INSECTICIDES AND FUNGICIDES. Ann. Survey Amer. Chem. 1928–1929. 4: 358–382. 1930.

Mention is made of the work of Dean and Schenk (*114*) and Roark and Nelson (*412*) with chloropicrin (p. 373).

——— (410)
INSECTICIDES AND FUNGICIDES. Ann. Survey Amer. Chem. 1930. 5: 398–421. 1931.

Refers to articles by Back and Cotton (*36*); Cotton (*108*); Roark and Nelson (*413*); and Gersdorff on the subject of chloropicrin.

——— (411)
NEW FUMIGANTS FOR DESTROYING INSECT PESTS IN FOODSTUFFS. Food Industries 3: 398–399. 1931.

Chloropicrin is mentioned as a fumigant which has been proposed for fumigating grain. On account of its persistent irritating odor it has never come into extensive use for treating foodstuffs.

——— and NELSON, O. A. (412)
MAXIMUM WEIGHTS OF VARIOUS FUMIGANTS WHICH CAN EXIST IN VAPOR FORM IN A 1,000 CUBIC FOOT FUMIGATING CHAMBER. Jour. Econ. Ent. 22: 381–387. 1929.

At 32° F. under a pressure of 1 atmosphere, 3.4 pounds of chloropicrin can exist in the vapor phase in a 1,000 cubic foot chamber. The amounts at higher temperatures are also given (p. 384).

——— and NELSON, O. A. (413)
DENSITIES OF MIXTURES OF AIR AND VARIOUS FUMIGANTS. Jour. Econ. Ent. 23: 985–987. 1930.

The specific gravity (air=1) of a saturated mixture of air and chloropicrin vapor at 77° F. and 760 mm mercury pressure is 1.1458.

——— PARMAN, D. C., BISHOPP, F. C., and LAAKE, E. W. (414)
REPELLENTS FOR BLOWFLIES. Indus. and Engin. Chem. 19: 942–943. 1927.

In several tests made at different times, 599 screw worms, *Cochliomyia macellaria* Fab., were observed visiting fresh beef liver treated with chloropicrin diluted with nine times its volume of mineral oil (5 cc of the mixture to a 113-g cube of liver) as against 1,822 observed visiting adjacent untreated liver. Odorous compounds, such as essential oils, and highly irritating materials, such as chloropicrin, are not so effective as the materials which can absorb, adsorb, or inhibit the formation of the volatile compounds evolved by decomposing meat.

RONA, P. (415)
UBER KAMPFGASVERGIFTUNGEN. II. UBER ZERSETZUNG DER KAMPFSTOFFE DURCH WASSER. Ztschr. Gesam. Expt. Med. 13: 16–30. 1920.

Chloropicrin is not decomposed by water (p. 19–20).

ROSEN, S. S. (416)
HYDROCYANIC ACID AS A FUMIGANT. Soap 8: 111, 113, 115. 1932.

Based on figures said to have been compiled by various authorities (apparently in part by Strand (*461*)) a comparison is given of the relative toxicities of hydrogen cyanide, chloropicrin, ammonia, ethylene oxide, ethylene dichloride, and carbon disulphide. Hydrogen cyanide is stated to be 7.74 times as toxic as chloropicrin and 100.24 times as toxic as carbon disulphide.

ROVERIO, G. (417)
BREVI NOTE SUI GAS TOSSICI IMPIEGATI IN GUERRA E MEZZI PREVENTIVI E CURATIVI. Gior. Med. Mil. 66: 908–919. 1918.

The war gases are listed. Chloropicrin is included as a lachrymatory gas (p. 910).

RUSSELL, E. J. (418)
THE PARTIAL STERILIZATION OF SOILS. Jour. Roy. Hort. Soc. 45: 237–246. 1920.

Chloropicrin is of great value as a partial sterilizing agent. It is fatal to eelworms and wireworms, and harmless to plants. It promotes root action to a remarkable degree (p. 246).

RYBA, G. (419)
DER GASKAMPF UND DIE GASSCHUTZGERÄTE IM WELTKRIEGE 1914–1918. Montanistische Rundschau Ztschr. Berg- u. Hüttenw. 14: 30–33, 157–159, 179–181, 203–208. 1922.

A general summary of information on gases, including chloropicrin, used during the World War.

SAINT-SERNIN, M. (420)
DESINSECTISATION DES LOCAUX A TERRE PAR LA CHLOROPICRINE. Jour. Med. Bordeaux 96: 661–663. 1924.

Fumigation with chloropicrin at Sidi-Abdallah during 1921–1923 is described. A dose of 10 g per cubic meter was used to kill insects, or a dose of 17 g per cubic meter, with an exposure of 24 hours, to kill their eggs. Rooms must be sealed with paper to render them gas tight. The dry vapor of chloropicrin does not alter metals, fabrics, or colors.

SAL'DAU, P. Y., POSPELOV, V. I., PETROV, A. D., and ISACHENKO, V. B. (421)
DISINFECTION OF GRAIN AND FLOUR WITH CHLOROPICRIN AND OTHER VOLATILE SUBSTANCES. State Inst. Appl. Chem. (Moscow) Trans. 10: 90–107. 1928. [Abstract in Chem. Abs. 24: 896. 1930.]

The disinfection powers of ethyl acetate, chloropicrin, carbon tetrachloride, and carbon bisulphide are compared. Preliminary experiments were conducted with the insects *Calendra granaria*, *Callosobruchus* [*Pachymerus*] *chinensis*, and *Aleurobius farinae*. Chloropicrin is 8 to 10 times more toxic than carbon bisulphide. In vacant buildings the application of chloropicrin (10 cc to 1 m^3 of space) was fully effective. In a container on the top of grain or flour carbon bisulphide penetrates the fastest, but the chloropicrin is more toxic. The absorption of the insecticide is greatest in flour and least in lentils, with wheat, rye, and oats between the two extremes. Chloropicrin decreases the germination of wheat, has no effect on lentils, and stimulates the germination of oats. Chloropicrin is more efficient and cheaper than the other disinfectants tested. It is even superior in this respect to cyanide, as the chloropicrin can be used in separate rooms of a building without interfering with the other rooms.

SANDERSON, E. D., and PEAIRS, L. M. (422)
INSECT PESTS OF FARM, GARDEN, AND ORCHARD. 568 p. New York. 1931.

A brief description is given of the use of chloropicrin as a fumigant, based on the work of Strand (*457*, *459*). The authors state "Its future must depend rather on what is yet to be learned about it than on what is already known" (p. 51).

SCHEUERMANN, H. (423)
KRIEGSGASFORGIFTNINGENS SYMPTOMER. Forebyggelse og Behandling. Militaerlaegen 30: 25–55. 1924.

A list of war gases is given, among which is chloropicrin (p. 34). Chloropicrin has an irritating action somewhat between that of chlorine and phosgene. The symptoms of chloropicrin poisoning are described briefly (p. 40–41).

SCHIFF, R. (424)
DEGLI EQUIVALENTI CAPILLARI DEI CORPI SEMPLICI. Gaz. Chim. Ital. 14: 368–447. 1884.

Physico-chemical data are given (p. 413, 439, 447).

SCHINDLER, P., and TROUVELOT, B. (425)
RECHERCHES SUR L'EMPLOI DE LA CHLOROPICRINE COMME INSECTICIDE AGRICOLE. Ann. Epiphyties 7: 398–401. 1921.

Details are given of fumigation tests with chloropicrin against the following: *Nygmia* [*Liparis*] *phaeorrhoea; Aulacaspis* [*Diaspis*] *pentagona* on jasmine; *Coccus* [*Lecanium*] *hesperidum* on the branches and leaves of the orange tree; *Ceroplastes rusci* on the branches of the fig tree. Tests were made on the following plants: Apple tree, plum tree, myrabolan, wild quince tree, jasmine, rose bushes, orange tree, and camelia. The results indicate that disinfection of plants bearing nests of *Liparis* may become a commercial practice; but unsatisfactory results were obtained with the cochenilles. Oranges and figs were unaffected by the fumigant, but camelias and roses were very susceptible to injury.

SCHNEIDER, B. v. (426)
UBER DIE SCHMELZPUNKTE EINIGER ORGANISCHER VERBINDUNGEN. Ztschr. Phys. Chem. 19: 155–158. 1896.

The corrected melting point of chloropicrin is —69.2° C. (p. 158).

SCHULZE, H. (427)
DIE BEKÄMPFUNG VON TYROGLYPHUS MYCOPHAGUS (MEGNIN). Arb. Biol. Reichsanst. Land u. Forstw. 11: 179–184. 1922.

A concentration of 10 cc of chloropicrin per cubic meter, with 2-hour exposure, killed all forms of *T. mycophagus* infesting an experimental brood of *Tenebrio molitor.* A concentration of 5 cc of chloropicrin per cubic meter, with 2-hour exposure, killed *Tenebrio molitor*, however, so that fumigation proved unsuitable.

SECAREANO, S. (428)
SUR LA PRÉPARATION DU PHOSGÈNE A PARTIR DE LA CHLOROPICRINE.. UNE REÁCTION COLORÉE DE CELLE-CI. Bul. Soc. Chim. France 41: 630–631. 1927.

At 100° chloropicrin is decomposed rapidly by sulphuric acid containing 20 percent sulphur trioxide into phosgene and nitrosyl chloride. A 73-percent yield may be obtained in 35 minutes.

SEGUY, F. (429)
NOTE SUR UNE DERATISATION ET DISINSECTION DE NAVIRE PAR LA CHLOROPICRINE. Arch. Med. Pharm. Navales 111: 509–511. 1921.

A transport of 4,000-m^3 capacity was fumigated with 20 l of chloropicrin. All rats and fleas were killed, but airing for 24 hours was necessary before the boat was habitable.

SEIDEL, K. (430)
DIE BEKÄMPFUNG DES KORNKÄFERS (CALENDRA GRANARIA). Ztschr. Gesam. Getreidew. 15: 35–44. 1928.

Chloropicrin has about the toxicity of hydrocyanic acid against the granary weevil *Calendra granaria.* After 15 minutes' fumigation with air saturated with chloropicrin and three hours' standing, all the weevils are dead. According to Zacher, a week's exposure to a mixture of 20 cc of chloropicrin in a cubic meter of air will kill all grain weevils (p. 44).

SEMIKOZ, F. F. (431)
CHLOROPICRIN AS A DISINFECTANT, INSECTICIDE, AND RODENTICIDE. Gigiena i Epidemiologia (Moscow) 8: 42–48. 1929. [In Russian.]

Chloropicrin is recommended as a disinfectant, as an insecticide, and for ridding houses and ships of rats. It can be used for disinfecting and ridding clothes of insects. It is believed that the use of chloropicrin for these purposes will increase.

——— MALUISHEVA, A. I., and SHERISHORINA, S. I. (432)
THE DISINFECTION OF DWELLINGS AND CLOTHES WITH CHLOROPICRIN. Rev. Microbiol. et Epidémiol. 6: 72–81, 131–132. 1927. [In Russian with a summary in English.]

As chloropicrin appears to be a satisfactory fumigant for the destruction of plague bacilli and insects likely to transmit the disease, experiments were made to ascertain its effect on clothing and other articles. It is harmless to fabrics and metals even when used at high concentrations under conditions of maximum relative humidity. Huts were successfully treated by applying the fumigant as a fine spray. The dosage should vary according to the permeability of the structure; under fairly air-tight conditions, 19 cc of chloropicrin to a cubic meter will kill the eggs of fleas in 6 hours. Carbon disulphide is less effective and chlorine does not kill the eggs. Details are given of a bag suitable for fumigating clothing. It is made of rubber and is hermetically sealed by means of clamps. Liquid chloropicrin is introduced by means of small metal tubes at the corners, and the tubes are immediately corked.

——— STEPANOV, V. F., and SCHMIDT, B. N. (433)
LABORATORY DATA ON THE ACTION OF CHLOROPICRIN, CHLORINE, AND CARBON DISULPHIDE AS DISINFECTANTS AND EXPERIMENTS TO DETERMINE THEIR INFLUENCE ON THE INSECT FAUNA IN THE BURROWS OF GROUND SQUIRRELS. Rev. Microbiol. et Épidémiol. 6: 41–68, 128–130. 1927. [In Russian with a summary in English.]

Of the three gases tested chloropicrin gave the best results, all insects (cockroaches, bedbugs, and fleas) and rod-shaped plague bacilli being killed after 24 hours' exposure to a concentration of 0.019 cc per liter. At the strongest concentration tried, 0.019 cc, all insects and bacilli were killed within half an hour. The insecticidal and disinfectant properties of chloropicrin are practically equal and are not affected by temperature or humidity within the range of fatal concentrations and exposure.

Chloropicrin was also the most effective when tried on the ectoparasites and plague bacilli in the actual burrows of the ground squirrels. It is necessary, however, to improve the method of application, as even with much higher doses than those used in the laboratory positive results were obtained in but 22 percent of the burrows treated. The action of the gas depends on the speed with which it will penetrate through to the nests; atmospheric pressure, type of soil, and the plan of the burrow have to be considered.

SEYEWETZ, A., and CHAIX, E. (434)
SUR L'OXYDATION À FROID DES MATIÉRES COLORANTES EN MILIEU ACIDE, EN VUE DE LEUR DÉCOLORATION, PAR L'HYPOCHLORITE DE SOUDE. Bul. Soc. Chim. France (4) 41: 196–205. 1927.

Chloropicrin is formed by the action of sodium hypochlorite on nitrophenols (p. 197–205).

SHEPARD, H. H., and LINDGREN, D. L. (435)
ETHYLENE OXIDE-LIQUID CARBON DIOXIDE MIXTURE IN HOUSE FUMIGATION. Jour. Econ. Ent. 25: 138–139. 1932.

In 1930 a large residence near Minneapolis was fumigated with chloropicrin to rid it of carpet beetles. The gas clung to clothes in the wardrobes for several weeks. Furthermore, the beetles were not well controlled. "Carboxide," a liquefied mixture of ethylene oxide and carbon dioxide in gas cylinders, was tried in October 1931 at the rate of about 9.5 pounds per 1,000 cubic feet of space. The fumigation was successful both from the standpoint of ease of operation and of effectiveness of control. No live beetles have been found in this house since it was fumigated.

SHEPHERD, D. (436)
LIFE HISTORY AND BIOLOGY OF ECHOCERUS CORNUTUS FAB. Jour. Econ. Ent. 17: 572–577. 1924.

This bran beetle injures cereal products and is cosmopolitan in its distribution. The use of chloropicrin is the chief method of control in Canada.

SHIVER, H. E. (437)
CHEMICAL WARFARE. II. CLASSIFICATION, PREPARATION, AND PROPERTIES OF AGENTS. Jour. Chem. Ed. 7: 95–108. 1930.

Chloropicrin is described as a quick-acting nonpersistent lung irritant in a classification of chemical warfare agents. Its physical and chemical properties are briefly described. Exposure to a concentration of 2 mg of chloropicrin per liter of air for 15 minutes or less is a lethal dose (p. 101–102).

SHUFFLEBOTHAM, F. (438)
INFLUENZA AMONG POISON GAS WORKERS. Brit. Med. Jour. No. 3042, p. 478–479. 1919.

In a large Midland town only 4 percent of workers with chloropicrin, chlorine, and hydrogen sulphide had influenza, as compared with 68 percent of other persons. In the North Midland district there were only one or two cases of influenza among 650 persons working where chloropicrin was manufactured and where filling was also carried on, and these cases were of a very mild type. Workers engaged in the production of poison gases other than phosgene have enjoyed a very high degree of immunity from influenza infection.

SIBERT, W. L. (439)
THE HANDLING OF AMERICAN-MADE GAS. Jour. Indus. and Engin. Chem. 11: 381. 1919.

In June 1918, 705 tons of chloropicrin in bulk was shipped to the American forces in France. England was sold 900 tons and France 300 tons.

SILBERRAD, O. (440)
NOTE ON THE FORMATION OF HEXACHLORETHANE FROM CHLOROPICRINE. Chem. News 123: 271. 1921.

When hydrochloric-acid gas is passed through chloropicrin at 100° C. and the mixed vapor passed through a tube filled with pumice and heated to 400° C., the bulk of the chloropicrin is decomposed into phosgene, nitrosyl chloride, and nitric oxide. A small proportion, however, is converted into hexachloroethane.

SILLEVAERT, M. (441)
LES PROCÉDÉS MODERNES DE DÉRATISATION ET DE DÉSINSECTION. Bul. Serv. Med. Travail, Bruxelles 5–6 (3–4): 57–72. 1926. Also in Rev. Hyg. 50: 312. 1928.

Chloropicrin is an efficient fumigant, killing both rats and insects, but it is very difficult to remove from the air, several days being required in some cases.

SLOSSON, E. E. (442)
CREATIVE CHEMISTRY. 311 p. New York. 1920.

Of the war gases, chloropicrin was manufactured in largest amount in the United States. It was commonly loaded in a shell or bomb with 20 percent of tin chloride. Its method of manufacture is described, and a photograph is given of the chloropicrin plant at Edgewood Arsenal, where 31 tons of chloropicrin were made in one day (p. 224–226).

SMOLCZYK, E. (443)
DIE ANWENDBARKEIT VON ATEMFILTERN. Gasmaske 1: 113–114. 1929.

An industrial respiratory mask filled with active carbon and with a capacity of about 260 cc will absorb 30.4 g of chloropicrin. If part of the active carbon is replaced by diatomite impregnated with salt solution the capacity is 15.2 g of chloropicrin.

Smorodinzew, A. (444)

DIE DESINFIZIERENDEN EIGENSCHAFTEN DES CHLORPIKRINS. Ztschr. Desinfektion 21: 169–172. 1929. [Abstract in Chem. Zentbl. 100 (2): 1805. 1929.]

Chloropicrin is effective against vegetative forms of microbes, but spores are resistant. At 38° C. the disinfecting power of chloropicrin against serum is about twice that at 4°. Chloropicrin has high penetrative power. Detailed results are given in six tables.

Snyder, T. E., and Zetek, J. (445)

DAMAGE BY TERMITES IN THE CANAL ZONE AND PANAMA AND HOW TO PREVENT IT. U.S. Dept. Agr. Bul. 1232, 26 p. 1924.

In the case of the subterranean mound-building termites it might be well to experiment with chloropicrin (p. 23).

Sollman, T. (446)

A MANUAL OF PHARMACOLOGY. Ed. 3, 1184 p. Philadelphia. 1930.

The effects of chloropicrin upon the respiration, blood concentration, skin, and kidneys, its lachrymatory effect and its after-effects are discussed. Dilutions of 1 in 1,000,000 are detected by the eyes of most subjects (p. 145).

Spear, E. B. (447)

SOME PROBLEMS OF GAS WARFARE. Sci. Mo. 8: 275–283. 1919.

Lists chloropicrin as a war gas used in shells (p. 278).

Spencer, E. W. (448)

AN HISTORICAL LESSON. THE FIRST PROJECTOR GAS ATTACK UPON THE AMERICAN FORCES, FEBRUARY 26, 1918. Chem. Warfare 9 (3): 2–3. 1923.

Phosgene and chloropicrin were used separately and in mixture. The German green cross shell and the projector bombs used in this attack contained superpalite (diphosgene or trichloromethylchloroformate) (75 percent) and chloropicrin (25 percent) in shell, and a 50–50 mixture in mines. Chloropicrin is described as being cumulative in its action. Therefore long exposure to even very low concentrations may prove as dangerous as a short exposure to high concentrations.

Spencer, G. J. (449)

RESULTS OF SOME PRELIMINARY EXPERIMENTS WITH CHLOROPICRIN. Ent. Soc. Ontario, Ann. Rpt. 50: 18–21. 1919.

Exposure for 38 minutes to a concentration of chloropicrin, starting with 30 cc and ending with 50 cc to 675 cubic feet, in a greenhouse with high humidity, at 90° F., was fatal to the following plants: Dandelion in flower; Michaelmas daisy; wild vetch; curled dock; geranium; and cut boughs of willow. Thrips, geometrid larvae, leaf roller, cercopidae, immature cicadellidae, and flies were killed. Cercopids in untouched masses of spittle were not killed. Exposure to 3 pounds of chloropicrin per 1,000 cubic feet, at 55.8°, relative humidity 87, kills common red spider effectively in 8 minutes, but kills salvia host in 5 minutes. Exposure for 40 minutes kills coleus and begonia but does not kill all mealybugs. All these tests were made in daylight. Three pounds of chloropicrin per 1,000 cubic feet, at 66.2°, humidity 89, killed leaf hoppers and aphids on rose, common red spider on salvia, tarnished plant bug and mites on aster, and cutworms. The exposure was 30 minutes. Earthworms and millipedes were killed to a depth of 5 inches in soil after exposure for 11½ hours to a concentration of chloropicrin, 8.7 ounces per 1,000 cubic feet at 55.4°, relative humidity 88. Tests with various house furnishings showed chloropicrin to have a tendency to rust polished steel. The following insects were placed in cotton bags containing 2,000 g of pure wheat flour or 1,000 g of a mixture of flour and bran: Saw-toothed grain beetle (*Oryzaephilus* [*Silvanus*] *surinamensis*); meal worm (*Tenebrio molitor*); drug-store weevil (*Sitodrepa panicea*); confused flour beetle (*Tribolium confusum*); Cadelle larvae (*Tenebroides mauritanicus*); granary weevil (*Calendra granaria*). Exposure to a concentration of chloropicrin of 8.7 ounces per 1,000 cubic feet for 25 hours and 15 minutes, at 53.5°, relative humidity 88 to 81, killed all adults and larvae except 58.3 percent of the

SPENCER, G. J.—Continued.

RESULTS OF SOME PRELIMINARY EXPERIMENTS WITH CHLOROPICRIN—continued.

drug-store beetle pupae. A packet of Quaker Oats very heavily infested with meal-worm moth (*Plodia interpunctella*) at all stages of growth was exposed to a concentration of 8.7 ounces chloropicrin per 1,000 cubic feet for 24 hours, at 64°, relative humidity 86. All the pests were killed.

SPEYER, E. R. (450)

REPORT OF THE ENTOMOLOGIST. Expt. and Research Sta., Cheshunt, Herts, Ann. Rpt. 8, p. 45–57. 1922.

Methyl nitrite and chloropicrin had a permanent effect on common red spider (*Tetranychus telarius* L.) but it was necessary to use concentrations which damaged the plants. The adult whiteflies (*Trialeurodes vaporariorum*) were also killed by these gases (p. 54).

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ENTOMOLOGICAL INVESTIGATIONS. Expt. and Research Sta., Cheshunt, Herts, Ann. Rpt. 9, p. 69–81. 1923.

Common red spider (*Tetranychus telarius* L.) exposed to 5 cc of chloropicrin in a 4-liter jar for 100 minutes at 89° F. was rendered motionless; none of the young or adults recovered after 4 days. Chloropicrin at the rate of 5 fluid ounces per 1,000 cubic feet at 64 to 73° in a greenhouse killed all spiders except a few adults, but it also killed the plants.

SPINDLER, H. (452)

UEBER DEN AUSTAUSCH VON CHLOR, BROM UND JOD ZWISCHEN ORGANISCHEN UND ANORGANISCHEN HALOGENVERBINDUNGEN. Ann. Chem. 231: 257–285. 1885.

At ordinary temperatures calcium iodide and chloropicrin do not react, but at 45° a reaction begins, with the separation of iodine (p. 279).

SSYTSCHEW, G. D. (453)

EINWIRKUNG VON CHLORPIKRIN AUF KALIUMJODID. Jour. Chem. Indus. [Russia] 7: 1168–1169. 1930. [Abstract in Chem. Zentbl. 102 (I): 2188. 1931.]

The action of chloropicrin upon potassium iodide in methyl alcohol solution is as follows: $CCl_3NO_2+4KI \rightarrow CI_4+3KCl+KNO_2$
With potassium bromide and chloropicrin the following products are obtained: Carbon tetrabromide, bromopicrin, chlorodibromopicrin, and nitromethane.

STANER, P. (454)

THE DISINFECTION OF COTTON SEEDS. Bul. Agr. Congo Belge 21: 830–832. 1930. [Abstract in Chem. Abs. 25: 3763. 1931.]

The best means for disinfecting cottonseed appears to be the use of the Clayton gas apparatus or the modified Simons apparatus. Clayton gas is a mixture of sulphur dioxide and sulphur trioxide. The Simons apparatus is based on the disinfecting properties of hot air on the dry seeds. For a complete disinfection of the seeds one of the toxic gases, chloropicrin, carbon disulphide, or hydrogen cyanide can be used.

STENHOUSE, J. (455)

ON CHLOROPICRINE. Phil. Mag. and Jour. Sci. (3) 33: 53–57. 1848.

Stenhouse, the first to prepare chloropicrin, obtained it by adding an aqueous solution of picric acid to an excess of bleaching powder. Chloropicrin is also formed when picric acid is boiled with potassium chlorate and hydrochloric acid, when picric acid is boiled with aqua regia, when a stream of chlorine gas is sent through a hot aqueous solution of picric acid, and when picrate of potash is heated with a solution of hypochlorite of lime. Chloranil cannot be converted into chloropicrin by being boiled with nitric acid, aqua regia, or hypochlorite of lime. Boiled with either hypochlorite of lime or potassium chlorate and hydrochloric acid the following yield chloropicrin: Chrysammic acid; styphnic acid; and oxypicric acid of Erdmann. Chloropicrin is a highly refractive colorless oil, with a specific gravity of 1.6657; it affects the eyes and nose strongly; it is nearly insoluble in water, but dissolves readily in alcohol and ether. It is not acted upon by sulphuric, hydrochloric, or nitric acid in the cold; it is decomposed by metallic potassium, and slowly decomposed by alcoholic

STENHOUSE, J.—Continued.

ON CHLOROPICRINE—continued.

alkalies or ammonia; its boiling point is 120° C.; it may be heated to 150° without being decomposed. It is not flammable; it is decomposed by passing the vapor through a glass tube heated decidedly below low redness. Chloropicrin may be obtained from all substances which yield picric acid, such as indigo and its derivatives, salicin and its derivatives, coumarin, phenol, creosote, Botany Bay yellow resin, liquid storax, gumbenzoin, and balsam of Peru. It may be obtained also from all the substances which yield the styphnic acid of Will and Boettger, the oxypicric acid of Erdmann. These include gum asafoetida, galbanum, ammoniacum, sagapenum, purree or Indian yellow, the water extracts of Brazil wood, red sanders wood, logwood, and fustic. Chloropicrin may also be prepared from Schunck's chrysammic acid and consequently aloes. Stenhouse prepared chloropicrin by boiling Dammara resin with nitric acid, treating the resulting product with hypochlorite of lime, and digesting in nitric acid the resinous compound which chlorine forms with usnic acid.

STOLTZENBERG-BERGIUS, M. (456)

WAS JEDER VOM GASKAMPF UND DEN CHEMISCHEN KAMPFSTOFFEN WISSEN SOLLTE., Chemische Fabrik, Dr. Hugo Stoltzenberg, 30 p. Hamburg.

Phosgene, "Perstoff" (the trichloromethyl ester of chloroformic acid), and chloropicrin are described as war gases known as "Grünkreuzstoffe." The physical, chemical, and physiological properties of chloropicrin are given. During the World War it was used mostly in the following mixtures: 25 percent chloropicrin with 75 percent "Perstoff"; 50 percent chloropicrin with 50 percent phosgene; 80 percent chloropicrin with 20 percent tin, silicon, or titanium chloride. In Germany, chloropicrin was called "Klop" and in France, "Aquinite" (p. 18–19).

STRAND, A. L. (457)

CHLOROPICRIN—NEW FUMIGANT FOR MILL AND HOUSEHOLD INSECTS. Minn. Agr. Ext. Spec. Bull. 102, p. 2–19. 1926.

For the fumigation of mill machinery, chloropicrin is best applied by atomizing a mixture of it with carbon tetrachloride (equal volumes) by air under a pressure of about 15 pounds into the elevator heads while the machinery is still running. An exposure of from 6 to 12 hours should be allowed. Although 1 pound of chloropicrin per 1,000 cubic feet in tight elevator legs has killed 100 percent of the Mediterranean flour-moth larvae, a dosage of 5 pounds is recommended in order to kill the confused flour beetles. For fumigating upholstered furniture infested with the clothes moth (*Tineola biselliella* Hummel), chloropicrin may be atomized into a regularly equipped fumigating room, 2 pounds for each 1,000 cubic feet of space, or it may be applied with a hand sprayer. In houses 1¼ pounds of chloropicrin per 1,000 cubic feet and an exposure of 12 hours are used. The pressure tank should be placed outside the house and connected with the atomizers in the rooms.

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PRELIMINARY EXPERIMENTS ON THE USE OF CHLOROPICRIN AS AN INSECT FUMIGANT IN FLOUR AND CEREAL MILLS. Jour. Econ. Ent. 19: 504–510. 1926.

Chloropicrin at the rate of 5 pounds per 1,000 cubic feet, diluted with the same volume of carbon tetrachloride, when sprayed into elevator heads in a flour mill killed all Mediterranean flour-moth larvae (*Ephestia kuehniella* Zell.) in the elevators and machines, except in one horizontal conveyor where the webbing was so thick that circulation of the fumigant was impossible. Confused flour beetles (*Tribolium confusum* Duv.) were reduced in numbers, but not all were killed. Atomizing the chloropicrin into the heads of the elevators while the machinery is running was the best method of application.

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A COMPARISON OF THE TOXICITY AND THE DIFFUSION IN A COLUMN OF GRAIN OF CHLOROPICRIN, CARBON DISULPHIDE, AND CARBON TETRACHLORIDE. Minn. Agr. Expt. Sta. Tech. Bul. 49: 59 p. 1927.

Throughout a range of temperatures from 35° to 10° C., 1 pound of chloropicrin is more toxic to *Tribolium confusum* Duv. than 20 pounds of

STRAND, A. L.—Continued.

A COMPARISON OF THE TOXICITY AND THE DIFFUSION IN A COLUMN OF GRAIN OF CHLOROPICRIN, CARBON DISULPHIDE, AND CARBON TETRACHLORIDE—continued.

carbon tetrachloride and the lower the temperature the greater the relative toxicity. Throughout the same range of temperatures, chloropicrin at the rate of 1 pound to 1,000 cubic feet of space is less toxic than carbon disulphide at the rate of 15 pounds per 1,000 cubic feet. The greater the concentration of chloropicrin (between 1 and 3 pounds per 1,000 cubic feet), the greater is its toxicity to insects through a range in temperature from 35° to 10°. A decrease in temperature lowers the toxicity of carbon tetrachloride much more rapidly than that of carbon disulphide or chloropicrin. The time-temperature toxicity curve for each of the three is not a straight line. Between 35° and 10° the time increases at a greater rate toward the lower temperature. The downward diffusion of chloropicrin or carbon disulphide in a tight bin of wheat is not so rapid as ordinarily described; the concentration of the gas does not become stronger at the bottom of the bin than toward the top, but varies inversely with the depth below the surface of the grain. Absorption of the gases by the top layers of grain prevents their rapid downward movement. It is shown that the lower the temperature the greater is the absorption; therefore, temperature is an important factor in fumigation of grain aside from its relation to the toxicity of the fumigant or the activity of the insects.

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THE APPLICATION OF CHLOROPICRIN, THE CHLOROPICRIN-CARBON TETRACHLORIDE MIXTURE (CHAPMAN PATENT), OR OTHER MODIFICATION OF CHLOROPICRIN TO INDUSTRIAL FUMIGATION. Minn. Agr. Expt. Sta. Ann. Rpt. 38: 541. 1930.

The mechanics of application of chloropicrin and the physico-chemical processes governing the effectiveness of fumigation will be studied.

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MEASURING THE TOXICITY OF INSECT FUMIGANTS. Indus. and Engin. Chem., Analyt. Ed. 2: 4–8. 1930.

A method of measuring relative values of insect fumigants by comparing concentrations which kill 50 percent of the test insects, *Tribolium confusum*, in 5 hours is proposed. Expressed in milligrams per liter, these concentrations of certain fumigants are as follows: Hydrocyanic acid, 0.607; chloropicrin, 4.70; ethylene dichloride, 33; and carbon disulphide, 60.85.

STRAWINSKI, K. (462)

[CHLOROPICRIN, A POWERFUL INSECTICIDE.] Doswiadczaln. Rolniczego, 4, pt. 2, reprint 4 p. *Sine loco*, 1929. [Abstract in Rev. Appl. Ent. 17:402. 1929.]

This is a detailed discussion on the composition and properties of chloropicrin, and experiments made with this insecticide in various countries are reviewed. Its manufacture on a commercial scale has only recently been started in Poland.

SUICHEV, G. D. (463)

NEW SYNTHESIS OF METHYL VIOLET. Jour. Chem. Indus. [Moscow] 5: 72–73. 1928. [Abstract in Chem. Abs. 22: 3650. 1928.]

Chloropicrin is used in the manufacture of methyl violet.

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REACTION OF CHLOROPICRIN AND POTASSIUM IODIDE. Jour. Chem. Indus. [Moscow] 7: 1168–1169. 1930. [Abstract in Chem. Abs. 25: 4219. 1931.]

The reaction between chloropicrin and potassium iodide (or sodium iodide) proceeds thus: $CCl_3NO_2+4KI=CI_4+3KCl+KNO_2$. Chloropicrin and potassium iodide in methyl alcohol are poured together and allowed to stand for 24 hours. The white precipitate is filtered off and the filtrate is allowed to stand for another 24 hours and then filtered. The combined precipitates are washed three times with methyl alcohol, air dried, and analyzed for potassium chloride and potassium nitrite. The filtrate is diluted with water, and the precipitate is then filtered off, dried, and analyzed for carbon tetraiodide. With one, two, or three mols of potassium iodide to one mol of chloropicrin are obtained carbon tetraiodide and no iodine-substituted chloropicrin. Analogous results are obtained in ethyl

SUICHEV, G. D.—Continued.

REACTION OF CHLOROPICRIN AND POTASSIUM IODIDE—continued.

alcohol and benzene; the reaction, however, proceeds with greater speed without the use of solvents. The reaction between chloropicrin and potassium bromide takes place very slowly. The formation of a precipitate is first observed after the mixture has stood in methyl alcohol for 15 days at 0°, but may be completed in 3 days by heating. The precipitate contains potassium chloride and much less potassium nitrite. The filtrate diluted with water deposits some carbon tetrabromide, bromopicrin, chlorodibromonitromethane, and other bromine substitution products.

SUZUKI, U. (465)

THE PROBLEM ON PROVISIONS. Rikwagaku Kenkyujo Iho v. 1, p. 38–45. 1922. [Abstract in Chem. Abs. 17: 2342. 1923.]

Chloropicrin is a good insecticide for use with stored rice.

SWEENEY, O. R. (466)

PROCESS OF MAKING CHLOROPICRIN. U.S. Patent 1,413,198, issued April 18, 1922; applied for November 11, 1920.

The author claims the process of making chloropicrin by bringing together under pressure a suspension in a water-comprising medium of a halogen-yielding material and suspensions in a water-comprising medium of picric acid and lime.

TATTERSFIELD, F., and ROBERTS, A. R. (467)

THE INFLUENCE OF CHEMICAL CONSTITUTION ON THE TOXICITY OF ORGANIC COMPOUNDS TO WIREWORMS. Jour. Agr. Sci. [England] 10: 199–232. 1920.

Chloropicrin is at least 500 times more toxic to insects than is chloroform and 350 times more toxic than nitromethane. From one to two millionths of a gram molecule of chloropicrin per 1,000 cc of air was toxic to wireworms (*Agriotes*) at 15° C., the exposure lasting 1,000 minutes. This is equivalent to 0.00016 to 0.00033 g per 1,000 cc. The authors conclude that compounds with irritating vapors such as allyl isothiocyanate, chloropicrin, and benzyl chloride, usually have high toxic values. The toxic values of these substances are not closely correlated with their vapor pressures. Next to allyl isothiocyanate, chloropicrin was the most toxic compound tested (p. 219).

TCHAYEFF, S. (468)

PREPARATION DE PRODUITS POUR L'IMPREGNATION, LA PROTECTION ET LA CONSERVATION DES MATIERES CELLULOSIQUES. French Patent 677,340, issued March 6, 1930; applied for October 17, 1928.

Sulphur dioxide, formaldehyde, and chloropicrin are mentioned as possessing energetic but transient disinfecting action. The patentee uses dinitronaphthol, dinitro-o-cresol, and similar phenols for preserving cellulose products.

THIEM, H. (469)

ZUR BIOLOGIE UND BEKÄMPFUNG DES GEFURCHTEN DICKMAULRÜSSLERS (OTIORHYNCHUS SULCATUS F.) Ztschr. Angew. Ent. 8: 389–402. 1922.

Chloropicrin has given good results, but its action on vines is so detrimental that it cannot be used. Nitrobenzene in combination with a small quantity (1 percent) of chloropicrin has been used (p. 399).

THIESING. (470)

KAMPFGASE UND WASSERVERSORGUNG. WASSER UND GAS. 12: 305–309. 1921.

Chloropicrin is insoluble in water, and injury will seldom result from the use of water containing it.

THILENIUS and POHL. (471)

UBER DIE DIFFUSION VON GASGEMISCHEN DURCH BAUMATERIAL. Ztschr. Angew. Chem. 38: 1064–1067. 1925.

The diffusion of mixtures of hydrocyanic acid gas with chloropicrin (11.2 mg HCN and 1.25 mg CCl_3NO_2 per liter) and with ethyl chlorocarbonate (11.2 mg HCN and 1.25 mg $ClCOOC_2H_5$ per liter) through building materials, such as brickwork, with and without plaster or wallpaper, was

THILENIUS and POHL—Continued.

UBER DIE DIFFUSION VON GASGEMISCHEN DURCH BAUMATERIAL—continued.

measured. The composition of the gas mixture was altered in passing through the material, the proportion of irritant usually decreasing. This is largely due to the influence of moisture and uncombined lime. The separation of the mixture is more pronounced with building materials containing many fine pores.

THOMAS, C. A. (472)

A REVIEW OF RESEARCH ON THE CONTROL OF WIREWORMS. Penn. Agr. Expt. Sta. Bul. 259, 52 p. 1930.

Reference is made to the work of Russell (*418*), Matthews (*295*), Hasson (*213*), and Tattersfield and Roberts (*467*) with chloropicrin as a fumigant against wireworms (p. 17).

THOMPSON, T. G., and BLACK, J. H. (473)

THE INTERSOLUBILITY OF CHLOROPICRIN AND WATER. Jour. Indus. Engin. Chem. 12: 1066–1067. 1920.

At 0° C. the solubility of chloropicrin in water is 0.2272 g per 100 cc, at 75° it is 0.1141 g per 100 cc. At 32° 100 g of chloropicrin dissolve 0.1003 g of water; at 55°, 100 g of chloropicrin dissolve 0.2265 g of water. The solubilities at intermediate temperatures are shown in curves. A method of analysis for the determination of chloropicrin in water is given.

THORPE, T. E. (474)

ON THE RELATION BETWEEN THE MOLECULAR WEIGHTS OF SUBSTANCES AND THEIR SPECIFIC GRAVITIES WHEN IN THE LIQUID STATE. Jour. Chem. Soc. [London] 37: 141–225. 1880.

The corrected boiling point of chloropicrin is 111.91° C. Density at 0°/0°, 1.69247, at 4°/4°, 1.69225. A table shows the relative volume of chloropicrin at every 5 degrees between 0° and 110°, being calculated from the formula $V=1+0.0011007\ t+0.000000465757\ t^2+0.000000007833\ t^3$ (p. 198–199).

TRABUT, L. (475)

A PROPOS DE LA DESINFECTION DES GRAINES DU COTONNIER. Bul. Agr. Algerie, Tunisie, Maroc 32: 1–2. 1926.

It is stated that the chloropicrin treatment of cottonseed as tested in France (see Vayssiére, and Mimeur) is useless against pink bollworm, *Pectinophora* [*Platyedra*] *gossypiella* Saund.

TRAPPMANN, W. (476)

SCHÄDLINGSBEKÄMPFUNG. 440 p., illus. Leipzig. 1927.

The physical and chemical properties of chloropicrin and its use against various insects are described. Reference is made to the work of Meyer (*304*), Wille (*520, 521*), and Dingler (*123*) (p. 366–368).

The proprietary preparation Hopikol is a mixture of carbon disulphide, nitrobenzene, and chloropicrin (p. 337).

Chloropicrin and methyl bromoacetate are added to hydrocyanic acid as warning agents (irritants). The maximum concentration of chloropicrin that can be tolerated is 10 mg per cubic meter (p. 351).

TRAUT, I. I. (477)

THE USE OF CHEMICAL SUBSTANCES FOR POISONING GROUND SQUIRRELS IN THE PLAGUE AREAS. Defense des Plantes 3: 537–551. 1926. [In Russian with a summary in English.]

The various substances, such as chlorine, carbon disulphide, and chloropicrin, used for the destruction of ground squirrels in their burrows have had no effect on their ectoparasites. Further work in connection with this problem is essential. Examination of burrows of various types discloses that the parasites occur in those containing a nest in good condition. Tight plugging of the burrows likely to contain the parasites is suggested.

TRAUT, I. I.—Continued. (478)

THE EFFECT OF CALCIUM CYANIDE ON THE ECTOPARASITES AND ASSOCIATES OF GROUND SQUIRRELS. RESULTS OF A STUDY ON METHODS FOR A SIMULTANEOUS DESTRUCTION OF GROUND SQUIRRELS, THEIR ASSOCIATES, AND ECTOPARASITES. Report of the Laboratory for the Study of Poison Substances, pt. 6, p. 18–19, 43–60. 1929. [In Russian, with summaries in English. Abstract in Rev. Appl. Ent. (B) 17: 157–158. 1929.]

Dosages of 0.5 g chloropicrin on pieces of cotton wool killed the ground squirrels, but did not affect the insect fauna of the burrows; 4-g dosages killed fleas only in nests built no farther than the middle of the second passage. As nests are usually built much beyond this, the percentage of fleas killed was negligible. The main cause of the ineffectiveness of chloropicrin is its ready absorption by the nest material and the soil.

TRONOW, B. (479)

ACTIVITY OF THE HALOGENS IN ORGANIC COMPOUNDS IN RELATION TO THE ELECTROCHEMICAL CHARACTER OF THE RADICAL WITH WHICH THE HALOGEN IS BOUND. Jour. Russ. Phys. Chem. Soc. 58: 1278–1301. 1926.

The activity of the halogen in chloropicrin in its reaction with pyridine and piperidine is studied (p. 1287, 1289, 1292).

——— and GERSCHEWITSCH, A. (480)

INFLUENCE OF ADMIXTURES ON THE VELOCITY OF THE REACTION OF HALOGENATED ORGANIC COMPOUNDS WITH AMINES. Jour. Russ. Phys. Chem. Soc. 60: 171–180. 1928.

The velocity of the reaction of chloropicrin with pyridine and with sodium methylate is studied (p. 174–177, 179).

TROUVELOT, B. (481)

RECHERCHES DE BIOLOGIE APPLIQUEE SUR LA TEIGNE DES POMMES DE TERRE & SES PARASITES ET CONSIDERATIONS GENERALES SUR L'UTILISATION DES INSECTES ENTOMOPHAGES EN AGRICULTURE. Ann. Epiphyties 10: 1–82. 1924.

Potatoes severely attacked by *Phthorimaea operculella* Zell should be treated with strong doses of fumigants, such as 80 g of carbon disulphide, or 10 g of chloropicrin per cubic meter (p. 32). The work of Vayssiere with chloropicrin is referred to.

TRUMBULL, H. L., and EVANS, W. L. (482)

PROCESS FOR MAKING CRYSTAL VIOLET. U.S. Patent 1,402,195, issued January 3, 1922; applied for September 16, 1919.

The process consists in mixing 1,645 parts by weight of dry chloropicrin with 3,630 parts by weight of dry dimethyl aniline. At the temperature of boiling water a little anhydrous aluminum chloride is added to the mixture, producing a violent interaction, with the evolution of brown and violet fumes. The residue after the reaction has ceased is crystal violet.

——— SEATON, S. G., and DURHAM, H. (483)

CONTROL EXPERIMENTS IN CHLOROPICRIN MANUFACTURE. II. ACTIVE CHLORINE IN THE SLUDGE FROM THE MANUFACTURE OF CHLOROPICRIN. Jour. Indus. and Engin. Chem. 12: 1068–1069. 1920.

A sludge of bleaching powder containing 6.98 percent active chlorine is reduced to 0.714 percent after a 2-hour steam distillation. The concentration of active chlorine in the sludge left in the chloropicrin stills at the end of the distillation is very low, usually less than 0.3 percent.

——— SOHL, G. T., BURT, W. I., and SEATON, S. G. (484)

CONTROL EXPERIMENTS IN CHLOROPICRIN MANUFACTURE. I. THE EFFECT OF VARYING QUANTITIES OF LIME UPON THE YIELD OF CHLOROPICRIN. Jour. Indus. and Engin. Chem. 12: 1068. 1920.

In these experiments, 30 g of picric acid, 300 g of bleaching powder, and 1,200 g of water were employed. An excess of lime (up to 30 percent excess) had no influence upon the yield of chloropicrin, which ranged from 1.67 to 1.82 for the ratio weight of chloropicrin over the weight of picric acid.

UNDERHILL, F. P. (485)

THE PHYSIOLOGY AND EXPERIMENTAL TREATMENT OF POISONING WITH THE LETHAL WAR GASES. Arch. Int. Med. 23: 753–770. 1919.

Chloropicrin is classified with chlorine, phosgene, and diphosgene as suffocating gas. Exposure to chloropicrin causes coughing, nausea, and vomiting, and in large quantity it may cause unconsciousness. Secondary effects are bronchitis, shortness of breath, a weak irregular heart beat, and gastritis. It may also cause acute nephritis. Liquid chloropicrin has a corrosive action on the skin, and scratches and abrasions exposed to chloropicrin fumes invariably become septic. Abscess formation may result. Chloropicrin injures the epithelium of the respiratory tract, especially the medium and small bronchi. An overwhelming edema of the lungs rapidly follows exposure to a lethal concentration of the gas.

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POISONING WITH THE LETHAL WAR GASES. PHYSIOLOGY AND EXPERIMENTAL TREATMENT. Jour. Amer. Med. Assoc. 73: 686–689. 1919.

The toxic action of chloropicrin is somewhere between that of chlorine and phosgene, both in regard to the type of influence provoked and in the rate of production of intensive edema. The detrimental influence of these gases is confined to the respiratory tract, and all the other effects must be regarded as secondary. The direct cause of death is the extreme concentration of the blood, which is brought about by edema. The treatment for chlorine and chloropicrin poisoning is early bleeding and infusion of salt solution.

——— (487)

THE LETHAL WAR GASES: PHYSIOLOGY AND EXPERIMENTAL TREATMENT. 309 p. New Haven. 1920.

Chloropicrin is a respiratory irritant and lachrymator. In its action it stands midway between chlorine and phosgene, being slower in its effects than chlorine but more rapid than phosgene. Chloropicrin injures the epithelium of the respiratory tract, the medium and small bronchi being most affected. There is a uniform widespread damage of the alveolar walls, which, however, is not severe enough to lead to necrosis. The alveoli are apparently nowhere protected by constriction of the bronchi. Overwhelming edema of the lungs rapidly follows exposure to the lethal concentration of the gas. In extreme cases practically every alveolus is filled with fluid. The action of chloropicrin on respiration, pulse, temperature, metabolism, blood concentration, etc., is given in great detail. The most efficacious method of treatment in chloropicrin poisoning is to bleed one half percent of the body weight as soon as possible after gassing and then to administer at once water by way of the mouth. Additional fluid may be supplied later by intravenous infusion of sodium chloride solution in accordance with hemoglobin readings and temperature changes. With this treatment there are no delayed deaths. The amount of chloropicrin vapor in air is determined by bubbling through 4 percent alcoholic sodium sulphite solution. All the chlorine in chloropicrin is converted into sodium chloride, which is then estimated by adding an excess of silver nitrate and titrating with ammonium sulphocyanate with ferric sulphate as an indicator.

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PHYSIOLOGICAL ACTION OF PHOSGENE, CHLORINE, AND CHLOROPICRIN. *In* The Medical Department of the United States Army in the World War, Medical Aspects of Gas Warfare v. 14, p. 307–355. Washington, D.C. 1926.

The data in this chapter will be found in The Lethal War Gases (*487*).

UNITED STATES INTERSTATE COMMERCE COMMISSION. (489)

IN THE MATTER OF REGULATIONS FOR THE TRANSPORTATION OF EXPLOSIVES AND OTHER DANGEROUS ARTICLES BY FREIGHT AND EXPRESS. Order 3666, December 22, 1925.

Paragraph 591 of the regulations is amended, effective February 1, 1926, permitting the shipment of chloropicrin and mixtures of chloropicrin with nonpoisonous liquids or gases in cylinders of not more than 120 pounds water capacity, nominal (p. 6).

URBAIN, E. (490)
SUR L'ABSORPTION DES VAPEURS PAR LE CHARBON. Compt. Rend. Acad. Sci. [Paris] 180: 63–65. 1925.

The absorption of the vapors of benzene, chlorine, and chloropicrin in charcoal is shown by curves.

VAN WINKLE, W. A., and SMITH, G. M. (491)
A SIMPLE, RAPID METHOD FOR THE DETERMINATION OF HALOGEN IN ORGANIC SUBSTANCES. Jour. Amer. Chem. Soc. 42: 333–347. 1920.

The chlorine in chloropicrin and other compounds is determined by volatilizing the material, and drawing it mixed with air through a heated quartz tube. The combustion products are absorbed in alkaline sodium sulphite solution. The excess of sulphite is oxidized. The halogen is determined by the Volhard volumetric method.

VAUGHAN, V. C. (492)
THE USE OF POISONOUS GASES IN THE PRESENT WAR. Jour. Lab. and Clin. Med. 3: 70–74. 1917.

Chloropicrin (p. 71) is classified with gases which produce slow death by asphyxiation. Gas masks, results of chlorine poisoning, and treatment of gassed patients are described.

VAYSSIERE, P. (493)
QUELQUES PROCEDES DE DESTRUCTION DES ACRIDIENS ET LEUR APPLICATION. Compt. Rend. Acad. Sci. [Paris] 169: 245–248. 1919.

Owing to recent ravages by the grasshoppers, *Dociostaurus maroccanus*, *Callipterus italicus*, and *Schistocerca tatarica*, official missions were organized to conduct experiments with a view to controlling these pests of agriculture. Spraying with a 25 percent, or, better, 50 percent, aqueous emulsion of chloropicrin has given excellent results.

——— (494)
LA LUTTE CONTRE LES CAMPAGNOLS DANS LES REGIONS LIBEREES EN 1919. UTILISATION DE LA CHLOROPICRINE. Compt. Rend. Acad. Agr. France 5: 885–889. 1919.

Chloropicrin has given good results for the destruction of field mice when used at the rate of 60 l per hectare. It was very successful when put in the holes of the field mouse and when sprayed over the ground.

——— (495)
INVASION DU CRIQUET MAROCAIN EN CRAU EN 1920. Rev. Vitic. 53 (1358): 28–31. 1920.

This article was presented by P. Marchal before the Academy of Agriculture at its meeting on June 2, 1920. Satisfactory results against the Moroccan cricket (*Dociostaurus maroccanus*) were obtained by spraying the ground with an aqueous solution containing 2 percent coconut-oil soap and 5 percent chloropicrin, but it was necessary to sprinkle the soil copiously.

——— (496)
LUTTE CONTRE LES SAUTERELLES. Bul. Soc. Étude et Vulg. Zool. Agr. 19 (3–4): 26–29. 1920.

This is an abstract of a report by Vayssiere presented by P. Marchal to the Academie des Sciences on August 4, 1919. Spraying with an aqueous emulsion of 25 percent, or, better, 50 percent, chloropicrin has given excellent results against grasshoppers in Crau.

——— (497)
LA CHLOROPICRINE CONTRE LES CAMPAGNOLS. Bul. Soc. Étude et Vulg. Zool. Agr. 19 (5): 39–40. 1920.

Chloropicrin sprayed on the ground from a knapsack sprayer was quite effective in killing field mice. In one test more than a thousand dead bodies were counted in 20 ares. In another test 60 field mice were killed on 1 are. [1 are is equivalent to 119.6 square yards.] About 60 liters of chloropicrin were used per hectare. [1 hectare is equivalent to 2.471 acres.]

VAYSSIERE, P.—Continued. (498)

LA LUTTE CONTRE LES INSECTES. Prog. Agr. et Vitic. (Ed. l'Est-Centre) 73: 614–615. 1920.

The use of chloropicrin against Moroccan crickets (*Dociostaurus maroccanus*) has been abandoned on account of the difficulties of application.

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LA LUTTE CONTRE LES SAUTERELLES EN CRAU. Rev. Hist. Nat. Appl. 1 (1): 337–341. 1920.

Chloropicrin gave excellent results in 1919 and was used in 1920 in the form of a 10 percent soapy solution. More than 5,000 l was sprayed.

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LA LUTTE CONTRE LE CRIQUET MAROCAIN (DOCIOSTAURUS MAROCCANUS THUMB) EN CRAU EN 1920. Ann. Epiphyties 7: 117–169. 1921.

Satisfactory results were obtained with an aqueous solution containing 10 percent chloropicrin and 20 percent coconut-oil soap. About 500 kg of chloropicrin was employed (p. 142–143).

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PROPRIETES INSECTICIDES DE LA CHLOROPICRINE; LEUR UTILISATION DANS LA DESINFECTION DES SEMENCES DE COTON. Agron. Colon. 7: 249–253. 1922.

Heat has been officially adopted in Egypt for the destruction of the "Ver rose" (*Pectinophora* [*Gelechia*] *gossypiella* Saund.). A dose of 30 g of chloropicrin per cubic meter effectively disinfects cottonseed exposed to it for 24 hours in a closed space without altering the germinating power. The adults, larvae, and pupae of *Phthorimaea operculella* (the larvae in potatoes) were killed by a dose of 10 cc chloropicrin per cubic meter.

——— and MIMEUR, J. (502)

SUR QUELQUES INSECTES NUISIBLES AU CONTONNIER EN AFRIQUE OCCIDENTALE FRANCAISE. Agron. Colon. 93: 89–125. 1925.

Treatment with chloropicrin is an effective measure against the pink boll worm, *Pectinophora* [*Gelechia*] *gossypiella* Saund. In further tests, 181 sacks of cottonseed were treated in four batches in a room 20 feet by 14 feet, all crevices being closed previously with strips of paper. The sacks were spread on the floor, each receiving a dose of chloropicrin, and then covered with a tarpaulin. It was found that 18 to 20 g of chloropicrin per sack killed all insects without affecting the germination of seed. The following were so treated in the sacks: Tenebrionid larvae *Reticulitermes* [*Leucotermes*] *lucifugus*, *Lepisna* sp. *Leptinotarsa decemlineata*, larvae of *Pieris rapae*, *Otiorrhynchus cingulatus*, *Palomona viridissima*, *Strachia ornata*, and aphids (p. 120–123, 125).

VIOLLE, H. (503)

DE LA CHLOROPICRINE COMME AGENT DE DERATISATION A BORD DES NAVIRES. Rev. Hyg. 48: 502–513. 1926.

Experiments in the fumigation of ships with chloropicrin are described. The conclusions reached are that the French authorities should permit the use of this fumigant. Chloropicrin delivered at Marseilles costs about 5 francs per kilogram. In fumigating, 10 g per cubic meter and an exposure of 12 hours give best results. Fumigated quarters should not be occupied until 24 to 48 hours after opening.

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DU POUVOIR ANTISEPTIQUE DE LA CHLOROPICRINE. Compt. Rend. Acad. Sci. [Paris] 182: 290–292. 1926.

An aqueous solution of chloropicrin (1.6 g per liter) has high antiseptic power. At the rate of 12 mg per liter of bouillon, chloropicrin prevents the growth of *B. coli*, *B. typhosus*, *B. paratyphosus*, staphylococcus, streptococcus, and other nonspore-forming bacteria. At the rate of 24 mg per liter of bouillon, chloropicrin prevents the growth of *B. subtilis*. Emulsions of *B. coli*, *B. typhosus*, *B. paratyphosus*, *B. dysentericae*, *B. proteus*, and *B. pyocyaneus* are killed after a 30-minute contact with chloropicrin, and *B. subtilis* is killed after contact for 1 hour. Chloropicrin retains its bactericidal power for several hours (in contradistinction to chlorine, iodine, and their derivatives) and does not coagulate egg albumen and other protein bodies.

VOELKEL, H. (505)
ZUR BIOLOGIE UND BEKÄMPFUNG DES KHAPRAKAFERS TROGODERMA GRANARIUM EVERTS. Arb. Biol. Reichsanst. Land u. Forstw. 13: 129–171. 1924

Used at the rate of 10 cc per cubic meter, Zyklon A killed in 6 hours, tetrachloroethane in 9 hours, and chloropicrin in 12 hours (p. 165).

WAHL, W. (506)
THE RELATION BETWEEN THE CRYSTAL SYMMETRY OF THE SIMPLER ORGANIC COMPOUNDS AND THEIR MOLECULAR CONSTITUTION—PART II. Roy. Soc. [London], Proc. (A) 89: 327–339. 1913.

Chloropicrin crystallizes in the shape of long thin needles possessing a strong double refraction and a parallel extinction. It thus belongs to the tetragonal, hexagonal, or orthorhombic systems. No other polymorphic modifications have been observed above —200° C. (p. 333).

WALDEN, P. (507)
UBER DEN ZUSAMMENHANG DER KAPILLARITATSKONSTANTEN MIT DER LATENTEN VERDAMPFUNGSWARME DER LOSUNGSMITTEL. Ztschr. Phys. Chem. 65: 257–288. 1909.

The specific cohesion of chloropicrin at its boiling point (385 absolute) is 2.82; the boiling constant *E* is 58.6; the latent heat of vaporization is 50.2 (p. 271).

WALKER, H. W., and MILLS, J. E. (508)
CHEMICAL WARFARE SERVICE BOLL WEEVIL INVESTIGATION. PROGRESS REPORT. Indus. and Engin. Chem. 19: 703–711. 1927.

The approximate toxic concentration of chloropicrin for the boll weevil was found to be 11.4 mg per liter with an exposure of 60 minutes. Assuming the value 0.33 cc as the amount of air breathed by a boll weevil in 1 hour, the toxic dosage of chloropicrin per weevil is figured as 0.0038 mg. Other fumigants tested were hydrocyanic acid, hydrogen sulphide, arsine, allyl iso-thiocyanate, and nicotine. The allyl iso-thiocyanate and the hydrocyanic acid were the most toxic (0.1 mg per liter) (p. 709).

WALLACH, O., and BOEHRINGER, A. (509)
VERHALTEN DES DIMETHYLOXAMIDES. Ann. Chem. 184: 50–51. 1877.

For the preparation of methylamine the authors used Geisse's procedure of reducing chloropicrin with tin and hydrochloric acid. A pure product and a good yield were obtained.

WARDLE, R. A. (510)
THE PROBLEMS OF APPLIED ENTOMOLOGY. 587 p., New York. 1929.

Formaldehyde, carbon disulphide, chloropicrin, dichlorobenzene, and cresol are used occasionally as fumigants but are in greater demand as sterilization agents (p. 204). The work of Moore, Strand, and Chapman and Johnson with chloropicrin is reviewed (p. 466–469).

WARREN, H. N. (511)
RECENT INVESTIGATIONS ON THE FULMINATES. Chem. News 57: 255–256. 1888.

Chlorine reacts with silver fulminate to form chloropicrin.

WATANABE, T. (512)
ACTION OF CHLOROPICRIN ON THE COCOON OF BOMBYX MORI. Nôgaku Kwaihô. Jour. Sci. Agr. Soc. (Japan), 234: 177–188. 1922. [Abstract in Chem. Abs. 16: 3213. 1922.]

The chrysalis in the cocoon, the maggot, and noxious insects accompanying it are killed with 1.5 to 2 pounds of chloropicrin in a closed vessel. The chrysalis thus obtained is blacker than that killed by steam, which is attributed to the formation of blackish-brown substances by the decomposition of the animal body by enzymes. Glycogen and proteins in the animal body are decomposed by an enzyme after death. The silk obtained from the cocoon treated with chloropicrin is coarse and slightly darkened in color as compared with that obtained by steam treatment. This can be remedied by using sodium phosphate and other treatment. In other properties and after treatment there is almost no difference by the two methods.

WEDEKIND, E. (513)

ÜBER EINE MIT GRÜNER CHEMILUMINESZENZ VERBUNDENE REAKTION. Ber. Deut. Phys. Gesell. 4: 417. 1906.

The reaction $3C_6H_5MgBr+Cl_3CNO_2=(C_6H_5)_3CNO_2+3MgBrCl$ is accompanied by a brilliant green luminescence.

WELLER, C. V. (514)

THE PATHOLOGY OF GASSING. Internatl. Assoc. Med. Mus. Bul. 7: 126–147. 1918.

Lists gases used in war and gives bibliography of 112 titles on gassing in warfare through 1917. Chloropicrin, acrolein, dibromoacetone, methylchlorosulfate, and probably other organic compounds have been used for their lethal effect. In general, they are irritants to conjunctival and respiratory mucosae and probably produce an asphyxial death through pulmonary edema (p. 138).

WERNER, A. (515)

ZUR FRAGE NACH DEN BEZIEHUNGEN ZWISCHEN FARBE UND KONSTITUTION. Ber. Deut. Chem. Gesell. 42: 4324–4325. 1909.

In an investigation of the colored compounds formed by the condensation of hydrocarbons with nitro compounds, tests were made with chloropicrin and tetranitromethane (p. 4325).

WEST, C. J. (516)

CHLOROPICRIN. War Dept. [U.S.], Chem. Warfare Serv., Chem. Warfare Monographs, v. 19, pt. 1, p. 1–169; pt. 2, p. 1–129. 1919.

A complete review of the literature and all War Department records. The manufacture of chloropicrin according to French, British, and American practice is described. Data on heat of solution in organic solvents are given. The absorbing power of linseed and other oils for chloropicrin is given. A mixture of 85 percent crude spindle stock petroleum oil and 15 percent chloropicrin by weight has no perceptible odor. This oil when treated with air saturated with chloropicrin at the rate of 1 l per hour absorbs chloropicrin up to 5 percent by weight.

WIELAND, H., AND JUNG, H. (517)

DAS SOGENNANTE NITRO-DIBROMÄTHYLEN UND ÜBER DEN REAKTIONSVERLAUF BEI DER BILDUNG VON BROM- UND CHLOROPIKRIN AUS POLYNITRO-PHENOLEN. Ann. Chem. 445: 82–92. 1925.

Chloropicrin is formed by the action of chlorine on 1,3,5-trinitro-2, 6-dihydroxybenzene.

WIENHAUS, H. (518)

VERFAHREN, FLÜSSIGE REIZSTOFFE IN FESTE FORM ZU BRINGEN. German Patent 441,553, issued March 4, 1927; applied for October 19, 1924.

Volatile tear gases are made into a solid or half solid form by means of solid hydrocarbons, fats, or waxes. For example, 1 kg of carnauba wax is melted with 4 kg of chloropicrin.

WILEY, H. W. (519)

PRINCIPLES AND PRACTICE OF AGRICULTURAL ANALYSIS. FERTILIZERS AND INSECTICIDES. Ed. 3, v. 2, 645 p. Easton, Pa. 1931.

Chloropicrin is included in a list of insecticidal fumigants. (p. 476).

WILLE, J. (520)

ZUR CHLORPIKRINFRAGE BEI SCHÄDLINGSBEKAMPFUNG. Deut. Landw. Presse 47: 564–565. 1920.

Wille has studied the action of chloropicrin on *Calendra granaria* and other insects.

——— (521)

CHLORPIKRIN IN DER SCHÄDLINGSBEKÄMPFUNG INSBESONDERE IN KAMPF GEGEN DEN KORNKAFER (CALENDRA GRANARIA L.). Ztschr. Angew. Ent. 7: 296–310. 1921.

The granary weevil is killed by a 6-hour exposure to a concentration of 30 cc chloropicrin per cubic meter. The germination power of the fumigated grain is diminished by 30 percent. For large stacks a concentration of 40 cc per cubic meter for 24 hours is necessary. The nutritive value and suitability for baking are not affected. Texture and color do not

WILLE, J.—Continued.

CHLORPIKRIN IN DER SCHÄDLINGSBEKÄMPFUNG INSBESONDERE IN KAMPF GEGEN DEN KORNKAFER (CALENDRA GRANARIA L.)—continued.

suffer. The chloropicrin vapor has completely disappeared 6 hours after treatment. Chloropicrin is also effective against the German cockroach (*Blattella* [*Phyllodromia*] *germanica*), the oriental cockroach (*Blatta* [*Periplaneta*] *orientalis*), the American cockroach (*Blatta* [*Periplaneta*] *americana*), the meal weevil (*Tenebrio molitor*), the Mediterranean flour moth (*Ephestia kuehniella*), bedbugs (*Cimex lectularius*), and caterpillars of *Malacosoma neustria* and *Dendrolimus pini*. Chloropicrin at a concentration of 30 cc per cubic meter has a strong action on "Brandsporen" (*Tilletia laevis*). Feeding experiments with mice and rabbits showed that treated grain can be used with impunity. Metals are acted upon by chloropicrin in the presence of aqueous vapor. Fabrics and colors do not suffer in any way. Compared with hydrocyanic acid gas, chloropicrin is slow in penetrating obstacles to diffusion and is more readily absorbed by fabrics.

——— (522)

CHLORPIKRIN ALS SCHÄDLINGSBEKÄMPFUNGSMITTEL IN SEINEN WIRKUNGEN AUF TIER UND PFLANZE. Naturwissenschaften 9: 41–48. 1921.

Reviews previous work by Bertrand and others. Wille has drawn curves showing the relative toxicity of chloropicrin to bedbugs, *Calendra*, *Tribolium*, rats, and fleas.

——— (523)

GASFORMIGE BEKÄMPFUNGSMITTEL GEGEN DEN KAFFEEBEERENKAFER. Anz. Schädlingskunde 1 (12): 139–141. 1925.

The use of cyanogas dust and chloropicrin against *Stephanoderes coffeae* Haged. in Brazil by Lehalleur is discussed (*266*).

WILLIAMS, C. L. (524)

A RAT AND A RAT-FLEA SURVEY OF SHIPS AT THE PORT OF NEW YORK. Pub. Health Rpts. [U.S.] 44: 443–476. 1929. [Abstract in Rev. Appl. Ent. (B) 17: 132. 1929.]

More than half and less than two thirds as many fleas per rat were found on rats killed with Zyklon B (hydrocyanic acid to which chloropicrin to the amount of 3 to 5 percent of the former has been added as a warning gas) as were found on rats killed by 80 percent hydrocyanic acid and 20 percent cyanogen chloride generated as a gas or sprayed as a liquid.

——— (525)

FUMIGANTS. U.S.Pub. Health Rpts. [U.S.] 46: 1013–1031. 1931.

Chloropicrin is the gas most commonly added to hydrocyanic acid as a warning agent. It seldom constitutes more than 5 percent of the mixture.

There are two distinct dangers connected with the use of warning gases. One is that when present in sufficient quantity to be actually intolerable, they constitute a menace to the fumigators, who may be rendered helpless by the effects of the warning gas. Tear gases, for example, may get inside a gas mask in sufficient amount to blind the fumigator. The other is that the warning gas may disappear before the hydrocyanic acid, so that fumigators misled by the absence of warning gas may declare a place safe when it is not.

——— (526)

EFFECT OF FUMIGATION ON COCKROACHES ON SHIPS. Public Health Rpts. [U.S] 46: 1680–1694. 1931.

In an experiment 22 cockroaches (*Blatella* [*Phylladromia*] *germanica*) were subjected to a concentration of 150 g of chloropicrin per 1,000 cubic feet for 40 minutes. For a few minutes they were very active, but at the end of 10 minutes they had become sluggish in their movements. At the end of 40 minutes they were still moving their legs though most of them were on their backs. The next day, 9 were alive, and 13 were dead.

Chloropicrin mixed with hydrocyanic acid exerted no influence on the toxicity of the latter. In all experiments the death or recovery of the cockroaches resulted only as the hydrocyanic acid content was up to or below the lethal concentration. The mixtures tested contained 5 or 10 percent of chloropicrin.

WILLIAMSON, K. B. (527)
THE USE OF GASES AND VAPOURS FOR KILLING MOSQUITOES BREEDING IN WELLS. Roy. Soc. Trop. Med. and Hyg. Trans. 17: 485–519. 1924.

Chloropicrin vapor killed larvae of *Anopheles maculipennis* within a few hours at a concentration of about 1 in 2,000,000. At saturation strength larvae were killed within a minute of their rising to the surface. A 20-minute exposure was necessary to kill all larvae when the concentration of vapor was 0.005 g per liter at 23° C. In tests in uncovered wells in Palestine, chloropicrin at the rate of 0.17 avoirdupois ounce per square yard of water surface killed all *A. maculipennis* larvae and pupae in 22 minutes. The water surface was 3 feet below the ground level, and there was no wind. Tests made in galvanized cylinders 16 inches in diameter with chloropicrin allowed to evaporate from a wick in a floating evaporator indicated that a concentration of chloropicrin vapor below 1 in 5,000,000 would kill all mosquito larvae and pupae within a week. Evaporation of 10 g of chloropicrin per square yard of water surface annually would be necessary to maintain this concentration over the water in still air in a well with a shaft 10 feet deep. Chloropicrin evaporated from a cotton wick in an open artificial well 3 feet 6 inches deep killed all larvae and pupae of *A. maculipennis* and *Culex pipiens* within 3 days in an exposed place out of doors.

WILSON, R. E. (528)
ALUMINUM GELLIKE ABSORBENT AND PROCESS FOR MAKING SAME. U.S. Patent 1,540,446, issued June 2, 1925; applied for January 28, 1920.

Patentee claims a hard, rough, partly hydrated gellike material consisting essentially of aluminum hydroxide and also the process of producing it by washing a precipitated aluminum hydroxide, kneading, and drying at relatively low temperature and finally at a relatively higher temperature. This material is a good absorbent, comparing favorably with activated charcoal (with which it may be mixed if desired) against such gases as phosgene and chloropicrin.

——— (529)
CUPRIC GELLIKE ABSORBENT AND PROCESS OF MAKING SAME. U.S. Patent 1,540,447, issued June 2, 1925; applied for January 28, 1920.

The same as U.S. Patent 1,540,446, except that cupric hydroxide is used instead of aluminum hydroxide.

WINTERNITZ, M. C., FINNEY, W. P., and WISLOCKI, G. B. (530)
NOTE ON THE COMPARATIVE PATHOLOGY OF CHLOROPICRIN POISONING. *In* Collected Studies on the Pathology of War Gas Poisoning. p. 85–87. New Haven. 1920.

The comparative toxicity of chloropicrin for the rabbit, dog, cat, monkey, goat, rat, and guinea pig is shown. A goat exposed to a concentration of 2.34 mg chloropicrin per liter for 15 minutes survived for 4 hours and 10 minutes.

WITHERSPOON, M. G., and GARBER, C. Z. (531)
A DIGEST OF REPORTS CONCERNING THE TOXIC EFFECT OF CHLOROPICRIN. War Dept. [U.S.], Chem. Warfare Service Rpt. E.A.M. R.D. 3, 86 p. 1922.

A compilation of all available data on the toxic action of chloropicrin on man and laboratory animals. Chloropicrin is also known as trichlornitromethane, vomiting gas, aquinite, G 25, S-1, and PS. During the war chloropicrin was most frequently used in combination with phosgene and stannic chloride. Chloropicrin is just detectable by odor and irritation of the eyes at a concentration of 0.0084 mg per liter. In most cases lachrymation is not produced until the concentration becomes 0.0162 mg per liter. The concentration for irritation of the throat is 0.075 mg/l and for production of coughing 0.114 mg/l. The lowest lethal concentration for dogs for a 30-minute exposure is above 0.81 mg/l, with death in from 4 to 66 hours. With goats the minimum lethal concentration for a 30-minute exposure is 0.2933 mg/l and for a 3-minute exposure 7.334 mg/l.

YAMAMOTO, R. (532)
INSECTICIDAL USE OF CHLOROPICRIN. Rikwagaku Kenkyujo Iho 1: 1–8. 1922. [Abstract in Chem. Abs. 17: 2341–2342. 1923.]

By spraying chloropicrin into a storehouse used for rice, wheat, etc., noxious insects are killed without bad effects on the goods. Generally about 0.225 to 0.35 g per cubic shaku is an effective quantity. The active period is 48–70 hours, and the higher the temperature the more effective it is. Experimental results performed on a large scale are given. Chloropicrin may also be used for killing pupae in cocoons.

ZACHER, F. (533)
DIE VORRATS-, SPEICHER-, UND MATERIALSCHÄDLINGE UND IHRE BEKÄMPFUNG. 366 p., illus. Berlin. 1927.

The use of chloropicrin against various insect pests is described. According to the Versailles Treaty the use of chloropicrin is forbidden in Germany (p. 335–336).

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